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ABSTRACT

To determine whether interrelationships existed among visual motor perception, linguistic skills, academic achievement, and the audiological status of deaf children, 199 subjects functioning from dull normal to superior in intelligence (aged 5.6 to 11) were studied. The results of the testing revealed that visual-motor-perceptual dysfunction is more frequently found in deaf than hearing children, and this lag does not seem to be the result of brain damage; a visual perceptual lag is more often found in those who test at a dull normal level; and a positive relationship exists between visual motor perception and intelligence, linguistic ability, and academic status. Some recommendations were that differential diagnostic testing should include assessment of visual motor perceptual functioning, training in this function should be emphasized throughout elementary school, motor encoding should be used for concept learning, a refined teacher evaluation scale for assessing language is needed, and further studies along these lines should be made. (Author/JM)

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RELATIONSHIPS AMONG AUDIOLOGICAL STATUS, LINGUISTIC SKILLS, VISUAL-MOTOR PERCEPTION, AND ACADEMIC ACHIEVEMENT OF DEAF CHILDREN

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SUMMARY

The basic objective of this study was to determine whether significant inter-relationships existed among visual-motor perception, linguistic skills, academic achievement, and audiological status of a group of deaf children. Furthermore, the study was concerned with (1) visual-motor deficits and their adverse effect on language acquisition and (2) exploration of instruments which can be used to predict language potential in a deaf child.

The 199 subjects included all children at the Texas School for the Deaf between ages 5-6 and 11-0 who functioned at least at a dull normal level of intelligence based upon an individually administered performance test.

Information on etiology, hearing level, previous education, intellectual functioning, and socioeconomic index was obtained from school records. Information on time of onset and etiology revealed that 23.6% were congenital endogenous, 26.7% were congenital exogenous, 8.5% were adventitious, and 41.2% were prelingual undetermined. Average hearing levels ranged from 28 to 110+ dB with only 27% having a best binaural average (BBA) of better than 80 dB. The mean two-frequency binaural average was 91.1 dB. Estimates of intelligence ranged from dull normal to very superior with 21.6% in the dull normal range and the remaining 78.4% in the range of average or above. Twenty-five percent of the sample had attended preschools for the deaf. Socioeconomic index showed that only six percent of the fathers were classified as professional and technical workers, and 56.3% of the fathers had not completed four years of high school education.

Visual-motor-perceptual ability was measured by the Bender Gestalt Test for Young Children (Bender) and the Marianne Frostig Developmental Test of Visual Perception (Frostig). Linguistic skills of the sample were measured by the four visual-motor subtests of the Illinois Test of Psycholinguistic Abilities (ITPA) and the Teacher Evaluation of Communicative Ability (TECA). Academic achievement was determined by the Gates Primary Reading Tests (Gates) and an estimate of educational progress. Intelligence was measured by the Columbia Mental Maturity Scale (CMM) and an estimate from individual performance tests.

Data were plotted by age intervals to show frequency distributions of raw scores and scaled scores for the total sample. Fifty to 60% of 198 deaf subjects' Bender scores were below one standard deviation from the Koppitz' means. Sixty-five percent of the population obtained perceptual quotients below 90 on the Frostig. Forty-three percent obtained scaled scores of eight or below on Eye-Motor Coordination, 45% on Figure Ground, 71% on Form Constancy, 54% on Position in Space, and 30% on Spatial Relations. These data suggested with reasonable certainty that some developmental lag in measurable visual perception existed in the young deaf children tested in this study.

One hundred ninety-seven of the subjects were administered the ITPA, but only 140 fell within published age norms. The subjects who had scores which negatively deviated one or more standard deviations from the normative-data mean were 34% on Visual Decoding and Visual-Motor Association and 43% on Visual-Motor Sequencing, but only 18% on Motor Encoding. More deaf subjects had significant deficits on Visual-Motor Sequencing than on other subtests. Deaf subjects were not considered significantly deficient from the hearing sample on Motor Encoding.

Pearson Product Moment Correlation Coefficients were computed on scores of all subjects (122) from whom complete data had been obtained. Significant correlations were found between visual-motor perception and intelligence, visual-motor perception and linguistic ability, and visual-motor perception and academic status. The BBA was not significantly correlated with any of the variables. Multiple correlation analysis showed that the combination of the ITPA and the TECA was the most efficient multiple predictor of reading achievement.

Subject groups believed to represent low and high risk for brain damage were identified. Bender, Frostig, and CMM scores were compared. Mean differences ($\alpha=.05$) between the high-risk and low-risk groups were not significant for Bender or Frostig scores. Mean difference in CMM IQ's between the high-risk and the low-risk groups was significant ($p < .025$).

This study revealed that

(a) Visual-motor-perceptual dysfunction is more frequently found in deaf children than in hearing children, and this lag or dysfunction does not seem to be the result of brain damage.

(b) A visual-perceptual lag is more pronounced and more often found in children who test at a dull normal level.

(c) A positive relationship exists between visual-motor perception and (1) intelligence, (2) linguistic ability, and (3) academic status.

It is recommended that

(a) Differential diagnostic testing should include assessment of visual-motor-perceptual functioning.

(b) School experience should emphasize visual-motor-perceptual training and/or remediation throughout the age range of elementary-school children.

(c) Motor encoding should be utilized for concept learning and feedback.

(d) Refinement of a teacher evaluation scale for assessing language in a deaf child should be carried out.

(e) This study should be replicated on deaf subjects with a greater range of hearing level and with a better geographic representation.

Chapter I

BACKGROUND OF THE STUDY

Background and Need

Many deaf children, who have been judged to be within normal range intellectually on the basis of performance tests and who have been shown audiometrically to have a considerable amount of residual hearing, nevertheless, exhibit unusual problems in the acquisition of language. Traditional methods for evaluating probable academic success of deaf children have been global measures of intellectual efficiency on performance scales, and it is not known how these relate to specific ability to acquire linguistic skills.[1]

Tests of visual-motor perception have been found useful in predicting linguistic abilities in normal-hearing children.[2] Apparently, no extensive application of these tests had been made with deaf children. Since these tests have proved useful with normal-hearing children, their applicability to deaf children should be explored extensively because the learning of these children is primarily through visual and motor modalities.

Although written language tests reveal much of the linguistic skill of hearing children, research (Myklebust, 1964; Stuckless and Marks, 1966) has shown a delay in use of written language by deaf children prior to nine years of age. The relation of reading to use of verbal symbols by the deaf (Myklebust, 1964) and the high correlation between the expressive and receptive verbal function plus the realization that input must precede output substantiates reading scores as a measure of language acquisition.

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[1] For the purpose of this study, linguistic ability was considered the ability to decode (receptive understanding of words, gestures, pictures and other symbols which are seen and heard), to associate (mental manipulation of linguistic symbols), and to encode (ability to express ideas in words or in gestures).

[2] Visual perception was defined as the ability to recognize and integrate visual stimuli--a process that occurs at the higher brain centers and not in the receiving organ. For the purpose of this study, the stimulus was visual and the response required a motor act.

Studies have examined the assessment of written language of deaf students (Stuckless and Marks, 1966) and specific etiologies as they relate to intelligence and language (Myklebust, 1964; Rosenstein, Lowenbraun, and Jonas, 1967; Vernon, 1967), but no single investigation has used a series of standardized tests on a large enough sample to identify a diagnostic battery that could aid in predicting academic achievement of today's population of school-age deaf children.

It is obvious to any professional working with the deaf that the so-called school-age deaf population is changing. Danish and Levitan (1967) in their 1940 to 1961 study of the variation of the causes of deafness at the Pennsylvania School for the Deaf report the change in distribution. Congenital hereditary deafness remained quite stable (50%) while postnatal deafness decreased and perinatal and prenatal deafness increased. Prematurity increased sharply and has become the most prevalent cause (36.2%) of deafness in the school population. Vernon's study (1968) of the etiological background of 1,468 school-age deaf children in the California School for the Deaf showed that prematurity was a leading cause of hearing loss in that population. Other leading causes of deafness found in that study were meningitis, maternal rubella, and complications of Rh factor. All of these etiologies have been associated with brain damage and have presented additional educational problems.

Educational implications of some of the leading causes of deafness are best understood in light of current research. Weiner (1962) in a review of the literature on the psychological correlates of premature birth found that prematures were impaired on measures of intelligence and frequently exhibited personality disturbances. In addition, measures of reading and writing showed impairment that might reflect a perceptual disability. Knoblock, Rider, and Harper (1956) reported that 50.9% of the children with a birth weight of 1,501 grams (5 lbs. 8 oz.) were found to have neurological and intellectual defects when given physical examinations and the Gesell developmental examinations. In a follow-up study of a group of premature children, Douglas (1956) found that they scored lower than their control group on tests of intelligence and showed more inferiority on tests of reading.

Maternal rubella, although cyclic in incidence, maintains its place as a leading cause of deafness (Danish and Levitan, 1967). Congenital defects are more apt to occur during epidemics. In addition, Vernon (1968) found a prematurity rate of 43% in rubella-deafened children.

Rh incompatibility accounted for 3.1% of deaf children in Vernon's sample (1967). Rh factor deafness was further complicated by multiple handicaps whose incidence was 71.1%. The current populations of schools for the deaf are made up of 5% post-lingually deaf in contrast to the 40% of earlier years as reported by Vernon in 1968.

Although many schools have set up special classes or departments for children with language or learning problems (Rosenstein, Lowenbraun, and Jonas, 1967), there remains the problem of identifying these children early enough in their school life to provide new techniques or to augment traditional approaches to the education of the deaf.

Related Research

A survey of the literature has revealed four important concerns. First, no comprehensive survey of the audiologic status of deaf children in a residential school for the deaf had been made. Second, all identified reports on research in the area of language (Furth, 1964a; Furth, 1964b; Furth and Youniss, 1964) have been based, by and large, on selected samples from oral schools for the deaf. Third, deaf children have been tested primarily with procedures designed for hearing children (Silverman, 1964); however, these tests do not describe language-related aptitudes of the deaf. Fourth, research studies which have attempted to describe or identify language potential have not used remedial material in the area of visual-motor perception of the deaf. Furthermore, Levine (1963) stated that studies in progress had not concentrated on key problems nor had they provided global coverage at various stages of investigation by meticulously designed research conducted by trained researchers. Although there has been a wealth of research in the area of cognition and perception (Blair, 1957; Costello, 1957; Davidson, 1954; Furth, 1961; Furth, 1964a; Furth, 1964b; Furth and Youniss, 1964; Hayes, 1955; Myklebust and Brutton, 1953; O'Neill and Oyer, 1961; Olson, 1961; Tiffany and Kates, 1962), our survey of the literature has not revealed a study that has related visual-motor perception (as measured by standardized tests) to the measurable language attainment of a large group of deaf children. Silverman (1964) has pointed out the need to investigate visual perception as it relates to auditory perception.

The Bender Gestalt Test (Bender) has been used extensively with normal-hearing children, but a review of the literature reveals an extremely infrequent application of its effectiveness with deaf children (Gilbert and Levee, 1967; Jacobs, 1956). The Bender has been used to screen for school readiness (Baldwin, 1950; Harriman and Harriman, 1950; Koppitz, Mardis, and Stephens, 1961), to predict school achievement (Koppitz, 1960; Koppitz, et al., 1959), and to diagnose reading and learning problems (Koppitz, 1958). Koppitz (1964) stated that an examiner can evaluate a child's perceptual maturity, possible neurological impairment, and emotional adjustment from a single Bender protocol and further that "...a child's Bender performance is in no way affected by speech and hearing." The present investigators found only two studies in which the Bender was used with deaf children--an unpublished master's thesis by Jacobs (1956) and by Gilbert and Levee's study (1967) which reported that a hearing group performed significantly better than a deaf group,and these authors concluded that the Bender could be a valuable aid in the detection of visual-perceptual problems in deaf children.

With the exception of Marshall's (1968) current study, an examination of the literature pertaining to research with deaf children revealed no application of the Marianne Frostig Developmental Test of Visual Perception (Frostig) with this group of children. Frostig (1963) stated that

> ...the development of visual-perceptual processes is a major function of the growing child between ages three and seven and at this level, perceptual development becomes a most sensitive indicator of the developmental status of the child as a whole.

In analyzing and reviewing the literature on perception, cognition, and language in deaf children, Rosenstein (1961) stated that no clear picture of deaf children in the perceptual and cognitive domain had emerged.

Olson (1961) used the Illinois Test of Psycholinguistic Abilities, Experimental Edition,(ITPA), in an effort to determine its usefulness as a diagnostic instrument for aphasic and deaf children. He compared the behavior of receptive-aphasic children, expressive-aphasic children, and deaf children on this test. Significant differences between receptive aphasics and deaf groups were observed. Rosenstein, Lowenbraun, and Jonas (1967) administered the four visual-motor subtests of the ITPA to 193 deaf subjects having special communication problems and found them to be inferior to the normative population of hearing children. However, subjects with normal intelligence (90 and above) were found to be below the hearing normative population on only the visual-sequencing subtest of the ITPA.

Objectives of the Study

The basic objective of this study was to determine whether significant inter-relationships exist among audiologic status, linguistic skills, visual-motor perception, and academic status of selected groups of deaf children in a residential school. Other objectives included (a) identification of limits of prediction from the measures obtained, and (b) identification of other salient variables.

A number of educational implications should be derived from the results of the several tests:

(a) Techniques to predict language potential in deaf children.

(b) A better understanding of the relationship between problems in language acquisition and etiology, that is, Rh incompatibility, rubella, heredity, etc.

(c) If visual-motor perception deficits adversely affect language acquisition, then remediation materials should be adapted for the deaf.

Chapter II

DESCRIPTION OF THE SAMPLE

Introduction

The subjects for this study were drawn from all children between the ages of 5-6 and 11-0 attending the Texas School for the Deaf during the school years 1966-67 and 1967-68. The Texas School for the Deaf, which is the largest residential school for the deaf in the nation, is the only residential school in Texas and draws its population from the geographic areas of the state where state supported county-wide day classes are not available. During the course of this study, the total population of the school was approximately 660 students between the ages of 5 1/2 and 21 years.

The requirements for admission to the school for the deaf are as follows.

(a) The applicant must have a hearing impairment great enough to have precluded the normal acquisition of language.

(b) He must demonstrate at least low average intellectual ability or show the potential for functioning at such a level.

The team approach is utilized in deciding each applicant's eligibility according to the previously stated criteria. The team consists of educational administrators, supervisory teaching personnel, a psychologist, social worker, audiologist, and a houseparent supervisor. Prior to admission, each applicant is administered audiological, otological, and psychological evaluations. These results are then related to, and interpreted in the light of, relevant information such as the child's socioeconomic status, educational experiences, onset of deafness, and other factors which may further define his suitability for inclusion in an educational program for normal deaf children. Thus, the individual casework approach is the basis for deciding each applicant's eligibility, rather than an adherence to any rigidly defined cut-off points in psychological or audiological data.

The study involved the total population in the Lower School (preparatory grades) and those children under age 11 in the Middle School (primary grades--oral and manual, preparatory grades--manual) of the Texas School for the Deaf with the following exceptions:

(a) Children accepted for admission on a "strong trial basis" because of questionable intelligence test findings and who did not subsequently test at a minimum IQ of 80 on an individual performance test (Grace Arthur Point Scale of Performance Tests I or Leiter International Performance Test of Intelligence) were omitted.

(b) Subjects under 11 years of age in the Special Education Section of the School were not included unless at the beginning of the project they were in regular classrooms. Some of the subjects were subsequently transferred to the Special Education program but these subjects all had tested IQ's of at least 80.

These omissions limited the sample to subjects functioning with at least an IQ of 80. Thus, an effort was made to eliminate the double handicap of deafness and mental retardation.

The 199 subjects in the study included 165 residential pupils (82.9%) and 34 day pupils (17.1%).[1] Table 1 shows number, percentage, grade level, and methods of communication of the subjects in the study for the two academic years--1966-67 and 1967-68. Information from school records and the consultant services of an otologist formed the basis for the description of subjects included in this study.

Age, Sex, and Ethnic Distribution

When the study began, the sample included 199 children from 5-6 through 11-0 years of age distributed as follows:

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[1] The original sample numbered 217 subjects. Eighteen subjects were eliminated from the study. Fifteen subjects had IQ's below 80; one subject had unverified birthdate; one subject was untestable--emotionally disturbed; and one subject was untestable--legally blind.

Table 1. Grade level and method of communication of 199 subjects at the Texas School for the Deaf.

Grade Level and Communication Method	1966-67 N	1966-67 %	1967-68 N	1967-68 %
Preparatory Grades				
Oral	145	92	149	75
Manual	7	5	21	11
Primary Grades				
Oral	3	2	9	4
Manual	2	1	5	2
Special Education	0	0	15	8

Age Range	No. of Subjects
5-6 to 6-5	26
6-6 to 7-5	25
7-6 to 8-5	68
8-6 to 9-5	36
9-6 to 10-5	29
10-6 to 11-5	15

The study began in October 1966 and the final testing was completed in May 1968. The children who were admitted to the school following the initial phase of the study were tested as time permitted. Of the total sample, 109 were males (55%) and 90 were females (45%). The ethnic distribution of the sample consisted of 103 Anglo-Americans (51.8%), 58 Mexican-Americans (29.1%), and 38 Afro-Americans (19.1%).

Etiological Distribution

Information on etiologies was available from medical histories and case study forms. The information was provided by parents on the admission of the child, or it was obtained by district social workers in the field.

Daniel Powell, M.D., an Austin otologist, reevaluated the medical history information and performed otological examinations to arrive at the etiological classification that was used in this study. The etiological distribution revealed that 23.6% were determined to be congenital endogenous, 26.7% were congenital exogenous, 8.5% were adventitious, and 41.2% were prelingual undetermined. (See Table 2.)

Previous Education

Formal educational experience prior to admission to the Texas School for the Deaf was reported for 81 of the subjects (40.7%). Of the total sample, 50 subjects (25.1%) had attended preschool classes for the deaf, and 31 subjects (15.6%) had previous training exclusive of preschool. The remainder of the sample of 118 subjects (59.3%) had no educational experience prior to admission to the Texas School for the Deaf.

Table 2. Etiologies and time of onset of deafness for 199 subjects at the Texas School for the Deaf.

Time of Onset	Etiology	N	%
Congenital			
	Endogenous	47	23.6
	Rubella	22	11.1
	Prematurity	23	11.6
	Rh Factor	5	2.5
	Prenatal Virus	1	.5
	Multiple Congenital Defects	2	1.0
	Total	100	50.3
Adventitious			
	Encephalitis	1	.5
	Meningitis	12	6.0
	Meningoencephalitis	2	1.0
	Streptomycin Therapy	1	.5
	Trauma	1	.5
	Total	17	8.5
Prelingual			
	Undetermined	82	41.2

Intelligence

The school records included psychological reports on most subjects. The psychological reports included the names of tests administered, interpretation of results, and a general estimate of intellectual functioning. For various reasons, including the variety of tests used, IQ was not stated. Perusal of reports showed that for the sample the following performance tests of intelligence were used:

Test	N
Grace Arthur Point Scale of Performance Tests, I	126
Leiter International Performance Scale, Arthur Adaptation	33
Merrill-Palmer Scale of Mental Tests (Performance Items only)	38
Not reported	2
Total	199

The psychologist also frequently administered the Goodenough Draw-a-Man Test, the Vineland Social Maturity Scale, and the Benton Visual Retention Test, which no doubt contributed to the statement of "clinical impression of intelligence" (Estimate of Intelligence).

When no psychological report was in the school record or when tests were stated as questionable, project personnel in this study administered further individual performance tests of intelligence.

The intelligence level of 199 subjects in the study was then estimated as 21.6% dull normal, 34.2% average, 35.2% bright normal, 4.5% superior, and 4.5% very superior. No subjects below the dull normal level of intelligence were included in this study.

Audiometric Data

The school audiologist provided the data on hearing test results. Nine of the 199 subjects in the sample were unavailable for testing. Subjects were tested on an Allison Audiometer Model 21 in an Industrial Acoustics Company Model 403A audiometric test room. The audiometer was calibrated to the ISO 1964 standard. Calibration checks were accomplished with the Bruel and Kjaer Model 158 audiometer calibration unit. The maximum outputs (ISO 1964) of the

Allison Model 21 audiometer for 125 Hz through 8000 Hz, at octave intervals were 80, 90, 110, 110, 110, 110, and 90 dB. Pure-tone air-conduction and, where feasible, bone-conduction results were recorded for each subject. Speech reception and speech awareness threshold results (informal testing using live voice) were obtained on some subjects. The necessity of transporting subjects to the main campus of the school for hearing testing (a distance of five miles) precluded complete audiological workup for all children. Because speech audiometry was not attempted or was not possible for all subjects, pure-tone air-conduction results (500, 1000, 2000 Hz) were used to estimate the hearing level for speech. The estimate was derived by considering the three standard frequencies (500, 1000, and 2000 Hz) and by averaging the better (left or right) air-conduction thresholds at the two frequencies having the lowest (best) thresholds. This estimate was termed the best-binaural two-frequency average (BBA). If a child did not respond to any given frequency, the threshold was recorded as the maximum output of the audiometer at that frequency. Table 3 shows the distribution (number and percentage) of the 190 subjects whose BBA's fell within each of 10 ranges. The hearing levels (BBA) of the subjects ranged from 28 to 110+ dB. The mean BBA was 91.1 dB. As can be seen in Table 3, 90% of the children had BBA's of 70 or more dB and can, therefore, be considered as having severe hearing loss.

Socioeconomic Level of Family and Education of Parents

Table 4 provides a socioeconomic index based on occupation. When one considers the data from the U.S. Bureau of the Census (1965), it is interesting to note the small percentage (6.0%) of professional and technical workers among fathers of deaf children examined in this study as contrasted to 12.0% found in the male population in the United States (Wechsler, 1967). The information on the education of the parents (Table 4) was available on 172 subjects. The largest proportion of fathers (56.3%) and mothers (58.3%) had not completed four years of high school education as compared with 21% for a sample of all Texas adults over 25 years of age in 1960.

Table 3. Distribution of hearing levels (best-binaural two-frequency average) of 190 subjects at the Texas School for the Deaf.

BBA Range in dB	Number	Percentage
20- 29	1	1
30- 39	1	1
40- 49	0	0
50- 59	4	2
60- 69	11	6
70- 79	25	13
80- 89	29	15
90- 99	49	26
100-109	54	28
110+	16	8
Total	190	100

Table 4. Socioeconomic level of 199 deaf subjects' families.[2]

	Occupational Categories[3]	N	%
I.	Professional, technical, and kindred workers	12	6.0
II.	Managers, officials, and proprietors (except farm)	18	9.1
III.	Clerical, sales, and kindred workers	14	7.1
IV.	Craftsmen, foremen, and kindred workers	38	19.1
V.	Operatives and kindred workers	43	21.6
VI.	Service workers, including private household	17	8.5
VII.	Farmers and farm managers	3	1.5
VIII.	Laborers, including farm laborers	51	25.6
IX.	Unemployed	3	1.5
	Total	199	100.0

[2] In determining the occupational category for a case in the sample, the occupation of the child's natural father was asked for, regardless of his current family status; if this information was not obtainable, the case was classified according to the mother's occupation.

[3] The occupational categories shown here were condensed from the 1960 Census groupings.

Chapter III

PROCEDURE

Introduction

Primarily the predictor variables were hearing loss (etiology and degree), visual-motor-perceptual ability as measured by the Bender Gestalt Test for Young Children (Koppitz, 1964) and the Marianne Frostig Developmental Test of Visual Perception (Frostig, 1964), and linguistic skills as measured by the Illinois Test of Psycholinguistic Abilities (McCarthy and Kirk, 1961). Criterion variables were a teacher-rating scale, academic achievement as measured by the Gates Primary Reading Tests (Gates, 1958), and an educational progress rating scale.

Because the estimated intelligence of subjects was based on a variety of instruments (see Chapter II), the Columbia Mental Maturity Scale was administered as a sole measure of intelligence for statistical purposes but not for selection purposes.

General Testing Procedures

The entire battery of tests was administered to all subjects enrolled in the Texas School for the Deaf in 1966. Subjects admitted to the School in 1967 were administered the tests appropriate to their age and grade level. Retests depended largely on the child's age and grade placement. No retest data are available on any subject admitted to the Texas School for the Deaf in 1967.

Limitations imposed by school routine, availability of test instruments, and the limited number of trained investigators involved in the study prevented the administration of all tests as a unit to all subjects.

The Bender Gestalt Test for Young Children (Bender), four visual-motor subtests of the Illinois Test of Psycholinguistic Abilities (ITPA), and the Columbia Mental Maturity Scale (CMM) were administered to the subjects individually in one session for each test. The Marianne Frostig Developmental Test of Visual Perception (Frostig) and Gates Primary Reading Tests (Gates) were administered in small groups of 6 to 10, in one session for the Frostig and two sessions for the Gates.

The order of tests of visual perception was as follows:

(a) The Bender Gestalt Test for Young Children (Bender)--This test was first administered to all subjects during the first two months of 1966. In 1967, new admissions were given the first test and the retests were completed on subjects who were given initial tests in 1966.

(b) The Illinois Test of Psycholinguistic Abilities (ITPA)--All four subtests were administered at one session in the order shown in the ITPA manual (McCarthy and Kirk, 1961). No retests were given.

(c) Marianne Frostig Developmental Test of Visual Perception (Frostig)--This was the third test administered and, as a result of late arrival, was first administered near the midterm of the 1966-67 school year. Retests were administered to the 1966 sample at midterm one year later.

The CMM was administered, depending on availability of subjects, during 1966 and 1967. The Gates Primary Battery was administered at midterm of each year.

Three psychologists and two educators of the deaf made up the team of examiners. One of the psychologists received extensive training to compensate for lack of experience with deaf children. The coordinating psychologist's background included seven years experience in residential schools for the deaf, and eight years evaluating children with communication disorders in a speech and hearing clinic. The coordinating psychologist was responsible for training and supervising the examiners. All test protocols were double graded by two psychologists and checked for clerical errors by the project secretary.

Specific Testing Procedures

The Bender Gestalt Test for Young Children (Bender) was selected as one clinical tool for assessing visual-motor-perceptual skills. The selection of the Bender was based on the following criteria.

(a) The Bender has been frequently employed as an indicator of possible neurological impairment, a condition which is often found in children manifesting learning disorders.

(b) There exists a vast body of research data regarding the use of the Bender with the hearing population. Such data provides a clinical baseline that permits a comparison of the deaf and hearing populations in terms of their relative visual-motor-perceptual skills.

The Bender drawings were presented according to the Koppitz (1964) directions with the addition of the following instructions:

(a) Gestures were used to communicate that the nine designs presented were to be reproduced.

(b) Practice designs were used with the subjects to reinforce Koppitz' directions (Appendix A).

All protocols were scored independently by two psychologists who used the Koppitz Developmental Bender Scoring System (Koppitz, 1964).

Marianne Frostig Developmental Test of Visual Perception (Frostig) was another test selected to measure visual perception. This test was selected because of the availability of norms on hearing children and its widespread clinical application. Observation of children attending the Marianne Frostig School of Educational Therapy has indicated that the most frequent difficulty these children experience is in the visual-perceptual area and that these disturbances appear to be related to learning difficulty (Frostig, 1964). The Frostig test was developed to specify the aspects of perceptual skill in which the child manifests deficiency.

The Frostig test identifies and measures, through the following subtests, five aspects of perceptual ability.

Subtest I--Eye-Motor Coordination (F_1)
This ability is measured by having the subject draw lines within increasingly narrow straight bands, angles, and curves.

Subtest II--Figure-Ground Perception (F_2)
This ability is measured by having the subject distinguish a single figure on a shaded background; the test then progresses to a more complex discrimination requiring the differentiation of intersecting figures. The subjects are asked to outline the hidden figures.

Subtest III--Form Constancy (F_3)
The subject must identify and outline all circles and squares on a page. This task requires the discrimination of circles from ovals, squares from rectangles, and a general survey of the entire page.

Subtest IV--Position in Space (F_4)
This perceptual function is assessed in two ways. First, the subject must mark a figure which faces a different direction from the majority of figures which are presented. Second, he has to identify figures which are positioned identically.

Subtest V--Spatial Relationships (F_5)
The subject is required to reproduce a vertical or horizontal line by connecting a series of dots.

The subtest raw scores were converted to scaled scores, perceptual ages, and global perceptual quotients (Frostig, 1964).

The Frostig was administered to groups of six to eight subjects by two psychologists who alternated as examiner and proctor. The general administration of the Frostig conformed to the instructions outlined in the test manual with the exception of additional gestures and pantomime necessary to reinforce and clarify the verbal instructions. Additional examples, shown in Appendix B, were also used until both psychologists were certain that all the subjects in the group understood the nature of the task.

The Illinois Test of Psycholinguistic Abilities (ITPA) included four visual-motor subtests which were selected as a measurement of nonverbal psycholinguistic abilities. The auditory-vocal subtests were not included because of the extreme, known degree of auditory impairment and language deficit of our subjects.

The four visual-motor subtests on the ITPA include the following.

(a) Visual Decoding (VisD)
This subtest purports to measure the child's ability to gain meaning from or comprehend visually presented material. The subject is shown a stimulus picture which is then removed. He is then asked to point to one of the four pictures after the examiner points to each picture. The correct answer is the one which

is most nearly identical on a meaningful basis, to the previously exposed stimulus picture. The examiners found that the instruction and demonstration items in the test manual were sufficient to assure understanding of the task by all of the subjects.

(b) Motor Encoding (ME)
Motor Encoding attempts to measure the ability of the child to express himself in gestures. The subject must gesture the manipulation of a real or pictured object. Pantomime was adequate to explain the task to the deaf subjects.

(c) Visual-Motor Sequencing (VMS)
Visual-Motor Sequencing is a test of immediate visual memory for a sequence of figures. The child must duplicate the order of a sequence of pictures or geometric designs that has been presented by the examiner and then removed. The instruction and demonstration items in the manual were adequate when accompanied by gestures which indicated "to think," "to remember," and "to make one like mine." The subjects were informed of success or failure in order to maintain motivation at a high level.

(d) Visual-Motor Association (VMA)
Visual-Motor Association measures the ability to relate common objects or pictures of common objects on a meaningful basis. The child is presented a single stimulus picture and a set of four optional pictures, one of which is associated with the stimulus picture. The examiner points to the stimulus picture, hesitates, and, with the other hand points to the four options, then gestures, "You point to one which goes with this one."

Raw scores were obtained for each subtest and these scores were converted to Language Ages in the ITPA manual (McCarthy and Kirk, 1961). When the subject's scores fell in the age range provided in the manual, raw scores were also converted to standard scores. Raw score tabulations were used in the frequency distribution analysis of subjects over nine years and three months and then means were converted to Language Age (LA) for comparative study.

The Gates Primary Reading Tests, Form 2 (Gates) were selected as testing instruments for the following reasons:

(a) Ease of group administration to deaf subjects.

(b) Availability of grade and age norms.

(c) Objective measurement of word recognition, sentence reading, and paragraph reading that is not dependent on a subject's auditory discrimination ability.

(d) Time limit per test which is generous.

(e) Directions which may be adequately supplemented, altered, or illustrated to assure clear understanding by the subject.

The Gates tests attempt "to reveal specific strengths and weaknesses in reading abilities and different phases of reading ability" (Gates, 1958). The three tests as described by Gates are as follows:

(a) Primary Word Recognition (PWR)
Word Recognition is designed to "sample the ability to read words representative of the primary vocabulary." The subject must circle one word out of four options which tells most about a pictured stimulus.

(b) Primary Sentence Reading (PSR)
Sentence Reading measures "ability to read sentences of increasing length and complexity." The subject reads the sentence of the test item and marks with a series of lines the picture which illustrates its meaning.

(c) Primary Paragraph Reading (PPR)
Paragraph Reading measures the ability "to read representative primary grade passages with reasonably thorough understanding." The subject must read a paragraph and then mark an illustration in such a way as to indicate the meaning.

Prior to testing, the subjects were taught the directions for taking the test by means of dittoed sheets and by the use of overhead projector transparencies. In order to insure understanding of directions, additional transparencies of sample material (see Appendix C) were shown prior to the administration of each section of the test. Subjects were tested in their regular classroom with the classroom teacher serving as proctor. The number of subjects tested at any one time numbered less than ten. The examiner gave each subject an opportunity to respond to each type of sample question presented on the overhead projector. More than one opportunity was provided for any subject who needed additional practice. The subjects' seating arrangement prevented one subject's seeing another's test booklet.

Following the practice work on the overhead projector, the sample page was completed by each subject. Each sample page was then checked for accuracy, and additional practice on the overhead projector was provided as needed. The overhead projector, oral directions, and finger spelling (in manual classes) were used to instruct the subjects. All other testing procedures were as specified in the examiner's manual (Gates, 1958). Raw scores for each test were tabulated and converted to reading ages and reading grades as given in the conversion tables of the Gates manual.

Columbia Mental Maturity Scale (CMM)--Because the extimated intelligence of subjects from school psychological reports was based on a variety of test instruments (see Chapter II), the CMM (Burgemeister, Blum, and Lorge, 1957) was administered as a sole measure of intelligence for statistical purposes, but not for selection purposes. This scale seems to be primarily a test of association ability which requires the subject to point to an item on a card that does not belong. Pantomime and lengthy demonstration of the lower-level items made it possible to begin on Item 31 and to obtain a basal score for most subjects. A few children did require beginning at a lower level in order to obtain a basal score. It is important to note that the examiners periodically asked the child to explain why he picked an item when attention was lagging. The examiner insisted that the child think and study before responding to each stimulus picture. Raw scores were tabulated and converted to mental ages and IQ's according to the instructions in the CMM manual.

Teacher Evaluation of Communicative Abilities (TECA)--A language evaluation, patterned after Mecham's scale (1957), was developed with specific items adapted to measure the expressive and receptive language development of young deaf children through their use of gesture, speech, speechreading, finger spelling, and conventional signs. The TECA scale is included in Appendix D. Items were chosen that are normally taught in the preparatory years at schools for the deaf. While the Mecham scale is an age-rated scale, TECA does not yield age scores since normative data will require standardization on a large sample of deaf children. For the purpose of this study, the TECA yielded the following scores: Expressive Score--number of items passed (highest possible score 29); Receptive Score--number of items passed (highest possible score 11); and Total Raw Score--the total receptive and expressive items passed (highest possible score 40). The classroom teachers were instructed in the use of TECA during a two-hour meeting with one of the investigators. TECA was specifically designed to provide a subjective overall evaluation of the language development of the first-year (First Prep) subjects.[1] However, use of this test was extended to all subjects in the Lower School with the expectation that it might provide an additional language score for the total sample.

The evaluation was completed on each subject in the Lower School during February 1966. This evaluation was not repeated during the second year of the study because of the excessive time that would have been required for the classroom teacher to complete an evaluation on each child.

Educational Progress Rating Scale--The supervising principal was requested to rate each subject's educational progress as below average, average, or above average. This estimate was based solely on the supervising principal's impression of the child in the total educational program, and it was completed at the conclusion of the study on a sample of 122 subjects in the Lower School.

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[1] The Gates Primary Reading Tests were not administered to first-year (First Prep) pupils at the Texas School for the Deaf.

Chapter IV

RESULTS*

All Subjects

The Bender Gestalt Test for Young Children (Bender)--The Bender was administered to 198 subjects. The Bender yields an error score which can be compared to the Koppitz (1964) normative data of (a) hearing children of the same chronological age, (b) hearing children with the same level of maturation in visual-motor perception, and (c) hearing children at a given grade level. Koppitz suggests that if a subject scores one standard deviation below the mean score of children of the same chronological age, this indicates a significant visual-motor-perceptual lag or dysfunction.

A comparison of the mean error scores and standard deviations of the 198 deaf subjects and Koppitz' data is given in Table 5. The data shown in Table 5 reveal a generalized visual-motor-perceptual lag or dysfunction at all ages tested. Fifty to 60% of all the deaf subjects' scores were below one standard deviation from the Koppitz means. The only age level where the mean approached Koppitz' mean plus one sigma was the five and one-half to six and one-half year age group. Standard deviations of the deaf subjects' scores were also generally larger than those of Koppitz' normative sample.

Similarity of growth curves of mean Bender Gestalt scores for normal and deaf subjects suggested equivalent sequential developmental stages for the two groups. The significant developmental lag continued through the age where no errors would be expected in a normal population. Bender norms (Bender, 1938) show that most children are able to copy all Bender designs at age eleven. Koppitz (1964) reported a mean error score of only 1.6 at age 9-6 to 10-5. The majority of our sample, even at age 10-6, did not attain this level. Actually, only 27% of the deaf sample at age 10-6 to 11-5 had error scores of two or less. However, between 30% and 31% of the 8-6 to 10-5 age groups had errors of two or less.

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*Computational procedures and formulas are shown in Appendix E.

Table 5. Mean error scores on the Bender Gestalt test for 198 deaf subjects and Koppitz' normative data.

Age	Deaf Subjects		Normal Subjects		% of Deaf Subjects Inferior to Koppitz
	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$ + SD
5-6 to 6-5 (N=26)	12.6	6.0	9.1	3.9	50
6-6 to 7-5 (N=25)	10.6	4.3	5.6	3.7	60
7-6 to 8-5 (N=67)	8.1	4.8	4.2	3.5	50
8-6 to 9-5 (N=36)	6.0	4.2	2.1	2.4	60
9-6 to 10-5 (N=29)	5.1	3.6	1.6	1.7	56
10-6 to 11-5 (N=15)	3.8	2.2	---	---	47

The Marianne Frostig Developmental Test of Visual Perception (Frostig)--This test was administered to 199 subjects. Raw scores on each subtest were first converted to perceptual ages, then to scaled scores (SS) and perceptual quotients (PQ) in accordance with instructions in the Frostig (1964) manual. Since no conversion tables are published for children over eight years of age, the scaled scores for these subjects were obtained by converting raw scores into perceptual age equivalents and dividing these by chronological age. If a child over eight years of age received the maximum perceptual age equivalent, he was assigned a scaled score of 10 for that subtest. Perceptual quotients were obtained for all subjects by doubling the sum of the scaled scores. Guidelines for interpretation of scores, according to Frostig (1964), are that PQ's below 90 and scaled scores of eight and below suggest a need for remediation.

Perceptual quotients for the 199 subjects ranged from 58 to 129 with a mean of 86.1 and a standard deviation of 12.1. Figure 1 shows the perceptual quotients of these 199 deaf subjects. Sixty-five percent of the population had PQ's below 90 indicating a visual-perceptual lag or dysfunction. Thirty-one percent obtained PQ's between 90 and 110. Only five percent of the sample obtained PQ's above 110. Thirty-six percent (70 subjects) thus obtained average or better PQ's.

Frequency and percentage of perceptual quotients under 90 for each age range are given in Table 6. Ages 5-6 to 6-5 and 6-6 to 7-5 had the lowest percentage of PQ's under 90. The 7-6 to 8-5 age group had the highest percentage (78%) of PQ's under 90. As can be seen in Table 7, the 6-6 to 7-5 age group obtained a mean perceptual quotient of 90.5. The lowest mean PQ (82.9) was obtained by the 9-6 to 10-5 age group.

Deaf children's best scores were obtained on Spatial Relations, Eye-Motor Coordination, and Figure-Ground Perception. However, on each subtest a greater percentage had need for perceptual remediation than would be expected in a normal-hearing sample as can be seen in Figure 2. This was most apparent on Form Constancy and Position in Space on which 73% and 55%, respectively, of the total sample had scores indicating need of perceptual training (Table 6).

The Illinois Test of Psycholinguistic Abilities (ITPA)--Each of the four visual-motor subtests of the ITPA were administered to 197 subjects. Raw scores and language ages were obtained on these 197 subjects. When the age of a

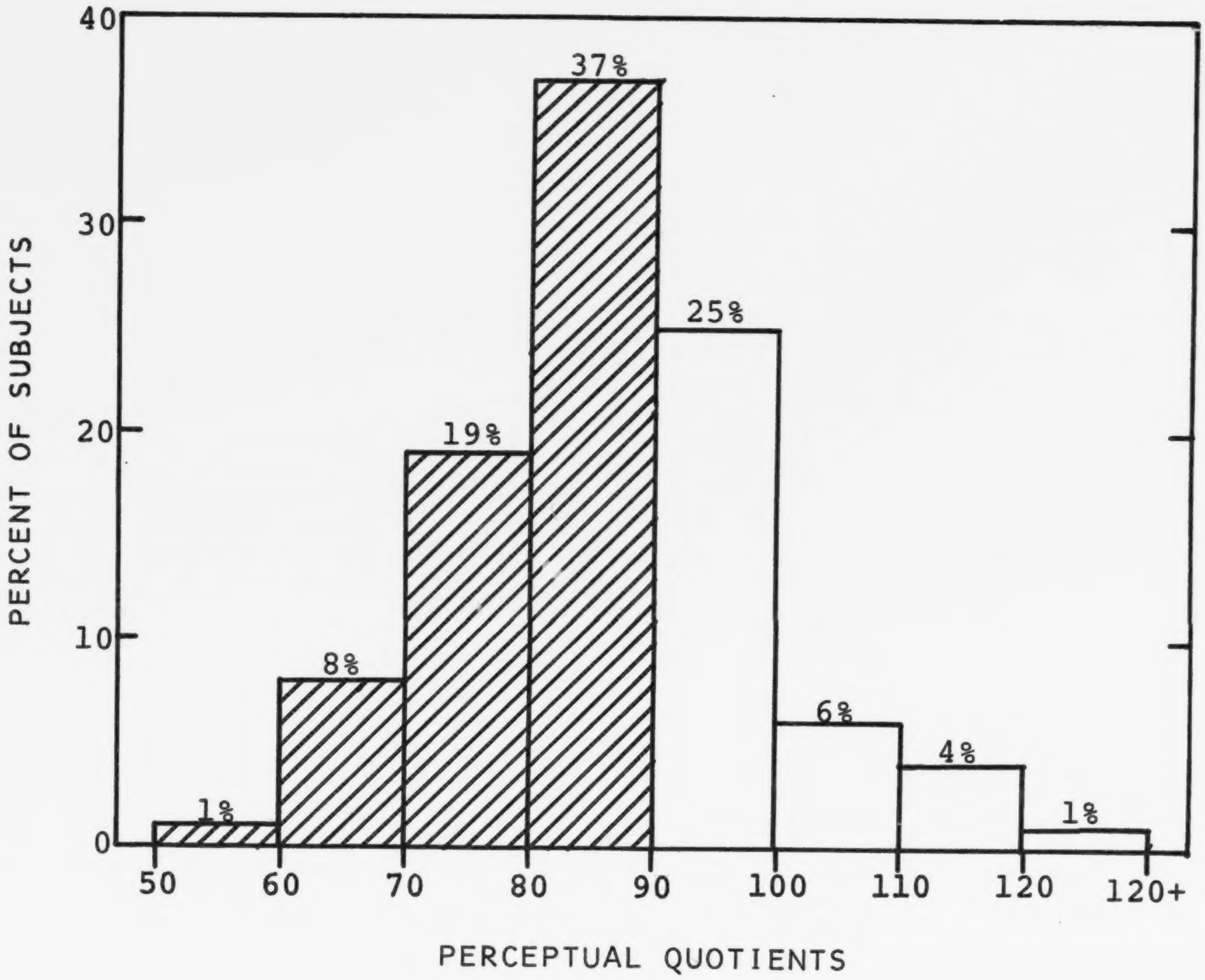

Figure 1. Distribution of Frostig full scale PQ's obtained by 199 deaf children. The shaded portions indicate inferior perceptual quotients.

Table 6. Frequencies* and percentages** of occurrence of scaled scores of eight or less and PQ's less than 90 on the Frostig test for 199 deaf subjects grouped by age.

Age	Frostig Subtests***					PQ***
	F_1	F_2	F_3	F_4	F_5	
5-6 to 6-5 (N=12)	4 *33%*	7 *58%*	5 *42%*	8 *67%*	4 *33%*	6 *50%*
6-6 to 7-5 (N=30)	9 *30%*	18 *60%*	18 *60%*	12 *40%*	9 *30%*	16 *53%*
7-6 to 8-5 (N=63)	31 *49%*	31 *49%*	50 *79%*	37 *59%*	17 *27%*	49 *78%*
8-6 to 9-5 (N=41)	22 *54%*	19 *46%*	27 *66%*	21 *51%*	12 *29%*	24 *59%*
9-6 to 10-5 (N=34)	13 *38%*	12 *35%*	26 *76%*	19 *56%*	13 *38%*	22 *65%*
10-6 to 11-5 (N=19)	7 *37%*	2 *11%*	16 *84%*	10 *53%*	4 *21%*	12 *63%*
Total (N=199)	86 *43%*	89 *45%*	142 *73%*	107 *55%*	59 *30%*	129 *65%*

*Roman type.

**Italic type.

***In the column labels of the table, F_1 = Eye-Motor Coordination, F_2 = Figure-Ground, F_3 = Form Constancy, F_4 = Position in Space, F_5 = Spatial Relation, and PQ = Perceptual Quotient.

Table 7. Mean scaled scores and standard deviations on Frostig subtests* for 199 deaf subjects.

Age	Means						Standard Deviations					
	F_1	F_2	F_3	F_4	F_5	PQ	F_1	F_2	F_3	F_4	F_5	PQ
5-6 to 6-5 (N=12)	9.5	8.1	8.8	8.4	10.0	89.7	1.8	2.0	2.0	2.7	2.0	14.8
6-6 to 7-5 (N=30)	9.6	8.6	8.4	9.1	9.8	90.5	1.7	2.0	2.2	2.3	2.1	18.1
7-6 to 8-5 (N=63)	9.0	8.6	7.4	8.3	9.1	84.2	2.1	1.5	1.4	1.7	1.4	10.9
8-6 to 9-5 (N=41)	8.6	8.8	8.1	8.5	9.2	86.5	1.9	1.4	1.6	1.6	1.1	10.0
9-6 to 10-5 (N=34)	8.8	8.7	7.1	7.9	9.0	82.9	1.6	1.8	1.8	2.0	1.4	10.5
10-6 to 11-5 (N=19)	9.0	9.6	7.1	8.0	9.3	85.7	1.4	1.1	1.5	2.1	1.5	7.3
Total (N=199)	8.9	8.7	7.7	8.4	9.3	86.1	1.8	1.7	1.8	2.0	1.5	12.1

*In the column labels of the table, F_1 = Eye-Motor Coordination, F_2 = Figure-Ground, F_3 = Form Constancy, F_4 = Position in Space, F_5 = Spatial Relation, and PQ = Perceptual Quotient.

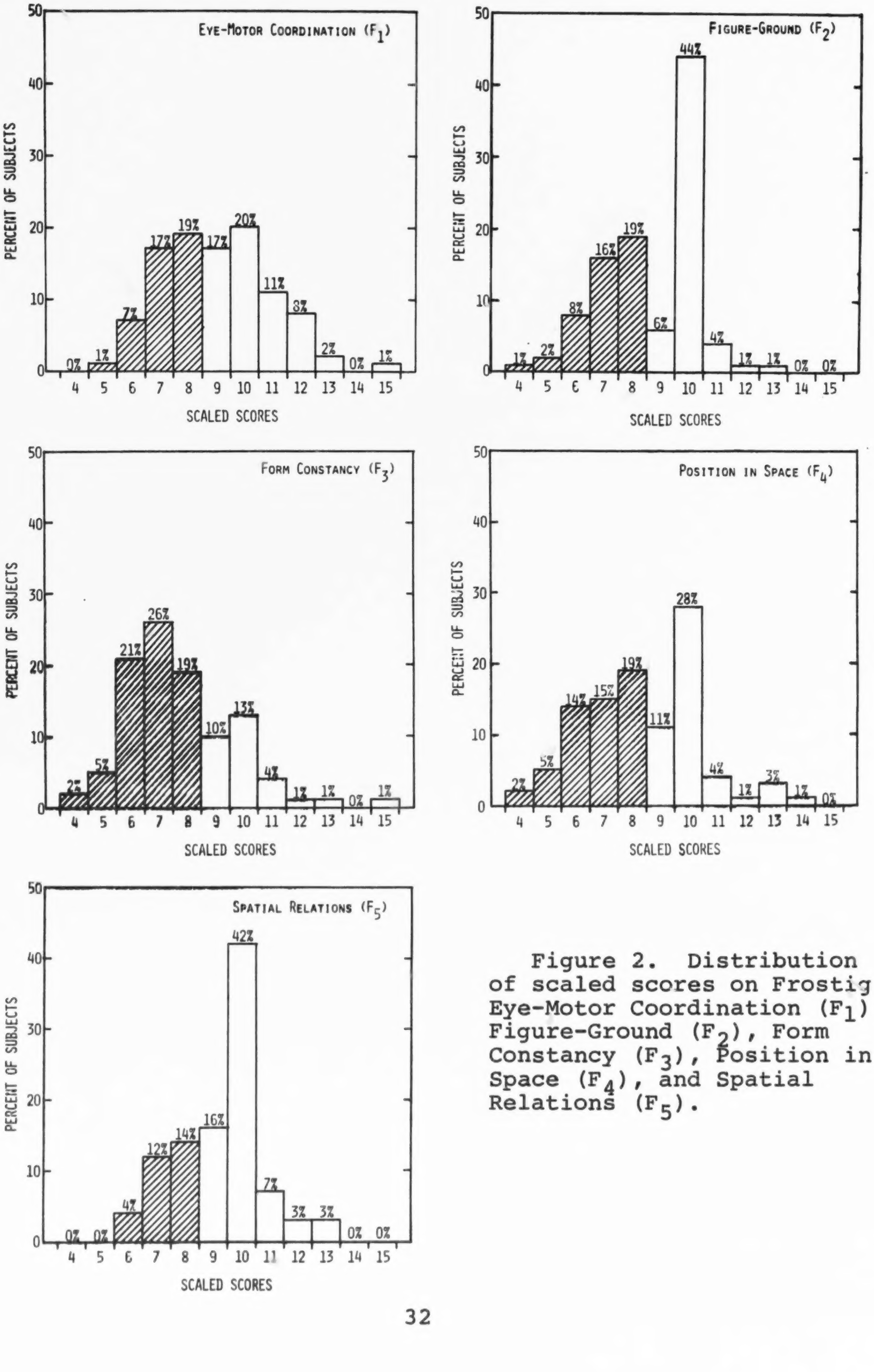

Figure 2. Distribution of scaled scores on Frostig Eye-Motor Coordination (F_1), Figure-Ground (F_2), Form Constancy (F_3), Position in Space (F_4), and Spatial Relations (F_5).

subject was within age levels of published norms (ceiling 9-3), raw scores were also converted to standard scores. One hundred forty of these subjects fell within the age range of published normative data (McCarthy and Kirk, 1961), and these subjects' performance will be discussed in the following section, *Selected Sample*.

Selected Sample. Standard scores for Visual Decoding ranged from -2.98 to 1.50 with a mean score of -.63 and a standard deviation of 1.13. This mean score is somewhat lower than a standard score of .00 for normals. Figure 3 depicts the percentage of the sample falling into each of the ranges of standard scores. It will be noted that 34% of the population had negative standard scores which fell one or more standard deviations from .00, and 12% of the sample obtained standard scores which negatively differ from .00 by more than two standard deviations.

Standard scores for Motor Encoding ranged from -2.64 to 1.60 with a mean of -.24 and a standard deviation of .93. The distribution of scores is shown in Figure 3, and this distribution is fairly symmetrical with 75% of the scores falling within one standard deviation of .00.

Standard scores for Visual-Motor Sequencing ranged from -2.69 to 2.05 with a mean standard score of -.76 and a standard deviation of .88. It will be noted in Figure 3 that 43% of the population had negative standard scores which fell greater than one standard deviation from the mean and 7% of the standard scores were below -2.00. Twenty-one percent of the population had positive standard scores which fell at or above .00.

Standard scores for Visual-Motor Association ranged from -3.00 to 1.33 with a mean standard score of -.69 and a standard deviation of 1.13. Figure 3 depicts the percentage of scores falling into each of the age ranges. It will be noted that 34% of the subjects scored more than one negative standard deviation from the mean for normals and 17% scored two standard deviations below .00.

Total Sample of 197 Subjects. For purposes of correlation, standard scores were also computed for the older subjects. Subjects over age 9-3 were treated as though they fell in the highest age range provided in the normative data (McCarthy and Kirk, 1961). This procedure introduces a slight systematic positive bias. However, as can be seen in Table 8, the means and standard deviations obtained were

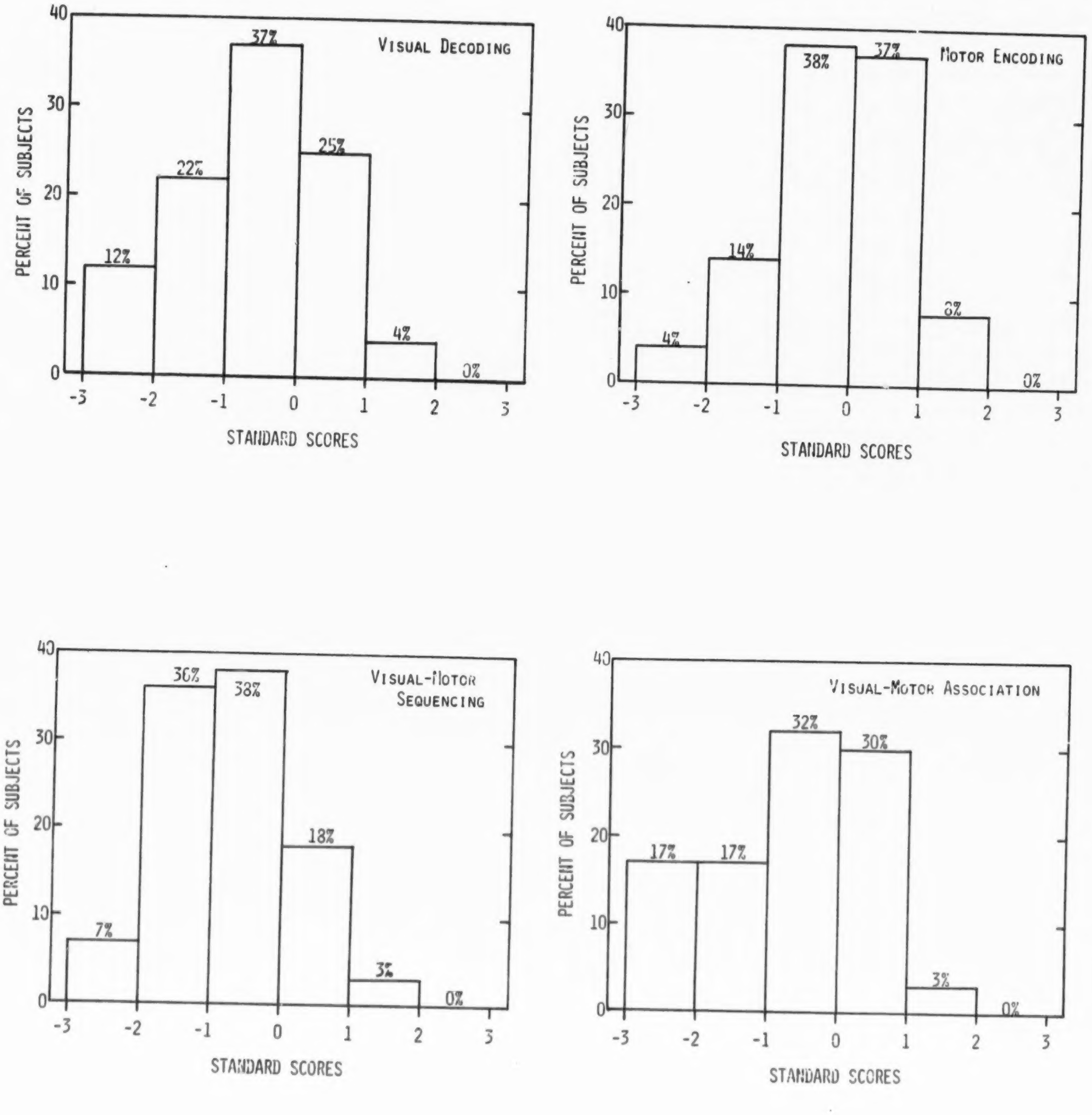

Figure 3. Distribution of standard scores on ITPA Visual Decoding, Motor Encoding, Visual-Motor Sequencing, and Visual-Motor Association.

Table 8. Comparison of standard scores for selected (N=140) and total (N=197) samples on ITPA subtest means and standard deviations.*

Statistic	Visual Decoding	Motor Encoding	Visual-Motor Association	Visual-Motor Sequencing
Mean Standard Score				
(N=140)	- .63	- .24	- .69	- .76
(N=197)	- .57	- .14	- .57	- .70
Range				
(N=140)	-2.98 to 1.50	-2.64 to 1.60	-3.05 to 1.33	-2.69 to 2.05
(N=197)	-2.96 to 1.82	-3.00 to 1.81	-3.00 to 1.58	-3.01 to 2.05
SD				
(N=140)	1.13	.93	1.13	.88
(N=197)	1.09	.93	1.07	.89

*Selected sample--subjects whose ages fell within the published age norms.

just slightly higher than for the 140 deaf subjects of comparable age to the normative sample.

Language Ages Compared to Chronological Ages. The deaf subjects performed on the Visual Decoding test at a level consistently inferior to hearing norms (McCarthy and Kirk, 1961). However, at ages 5-6 to 6-5, these subjects' performances fell within the standard error of measurement and, hence, were interpreted as not significantly different from the normative sample. However, when one considers progressively older age groups among our group of children, a greater discrepancy between the deaf and hearing appears. The scores on Visual Decoding for deaf were significantly inferior to hearing norms for the 6-6 to 11-5 age group (Table 9). This gap at older ages might be an experiential gap or a test artifact due to the ITPA ceiling at 9-3. Table 9 strikingly portrays the lack of significant discrepancy between performances on Motor Encoding by the deaf and the ITPA normative sample.

As one considers increasingly older age groups, the deaf subjects showed improvement in performance on Visual-Motor Sequencing, but from age 6-6 through 11-5 they are significantly inferior to the ITPA norms.

Our data showed that abilities in Visual-Motor Association improve with age in deaf children, but scores were consistently inferior to the normative sample. Significant gaps between ITPA norms and results for the deaf sample occurred from ages 6-6 through 9-5. A significant gap also appeared to be present at ages 9-6 to 10-5 and 10-6 to 11-5, but this gap might have been smaller if the ceiling for the test were higher.

The Columbia Mental Maturity Scale, Revised Edition (CMM)--The Columbia Mental Maturity Scale (CMM) was administered to 199 subjects. All raw scores were converted to IQ's (Burgemeister, Blum, and Lorge, 1957). Table 10 shows the mean IQ for each age group. CMM IQ's ranged from 50 to 140 with a mean IQ of 84.3 and a standard deviation of 16.4. Forty-five percent obtained IQ's below 80. Distribution of CMM IQ's for the entire sample is shown in Figure 4.

Gates Primary Reading Tests (Gates)--The Gates Primary Reading Tests were administered to 144 subjects. (First-preparatory children were not administered this test.) Table 11 shows mean scores and standard deviations for each age group.

Table 9. Lag in months between mean language age (ITPA subtests) and mean chronological age for one-year interval age groupings of 197 deaf subjects.

Age	ITPA Subtest			
	Visual Decoding	Motor Encoding	Visual-Motor Association	Visual-Motor Sequencing
5-6 to 6-5 (N=20)	4	4	9*	4
6-6 to 7-5 (N=23)	13*	7	14*	13*
7-6 to 8-5 (N=64)	17*	9	11*	17*
8-6 to 9-5 (N=37)	20*	3	13*	20*
9-6 to 10-5 (N=36)	25*	15**	20*	25*
10-6 to 11-5 (N=17)	36*	26**	36*	36*

*Deviation greater than the standard error of the mean for normative study (McCarthy and Kirk, 1961).

**These comparisons involved the age ceiling for the test, so no significance can be established for the magnitude of the apparent difference.

Table 10. Columbia Mental Maturity Scale mean IQ's and standard deviations by age level of 199 deaf subjects.

Age	Mean IQ	SD	% Below 80
5-6 to 6-5 (N=10)	91.4	16.0	10
6-6 to 7-5 (N=31)	86.9	13.3	32
7-6 to 8-5 (N=41)	81.7	11.8	42
8-6 to 9-5 (N=55)	87.3	19.3	36
9-6 to 10-5 (N=26)	82.8	18.4	46
10-6 to 11-5 (N=27)	78.0	16.4	56
11-6 to 12-5 (N=7)	85.1	14.1	43
Total (N=199)	84.3	16.4	45

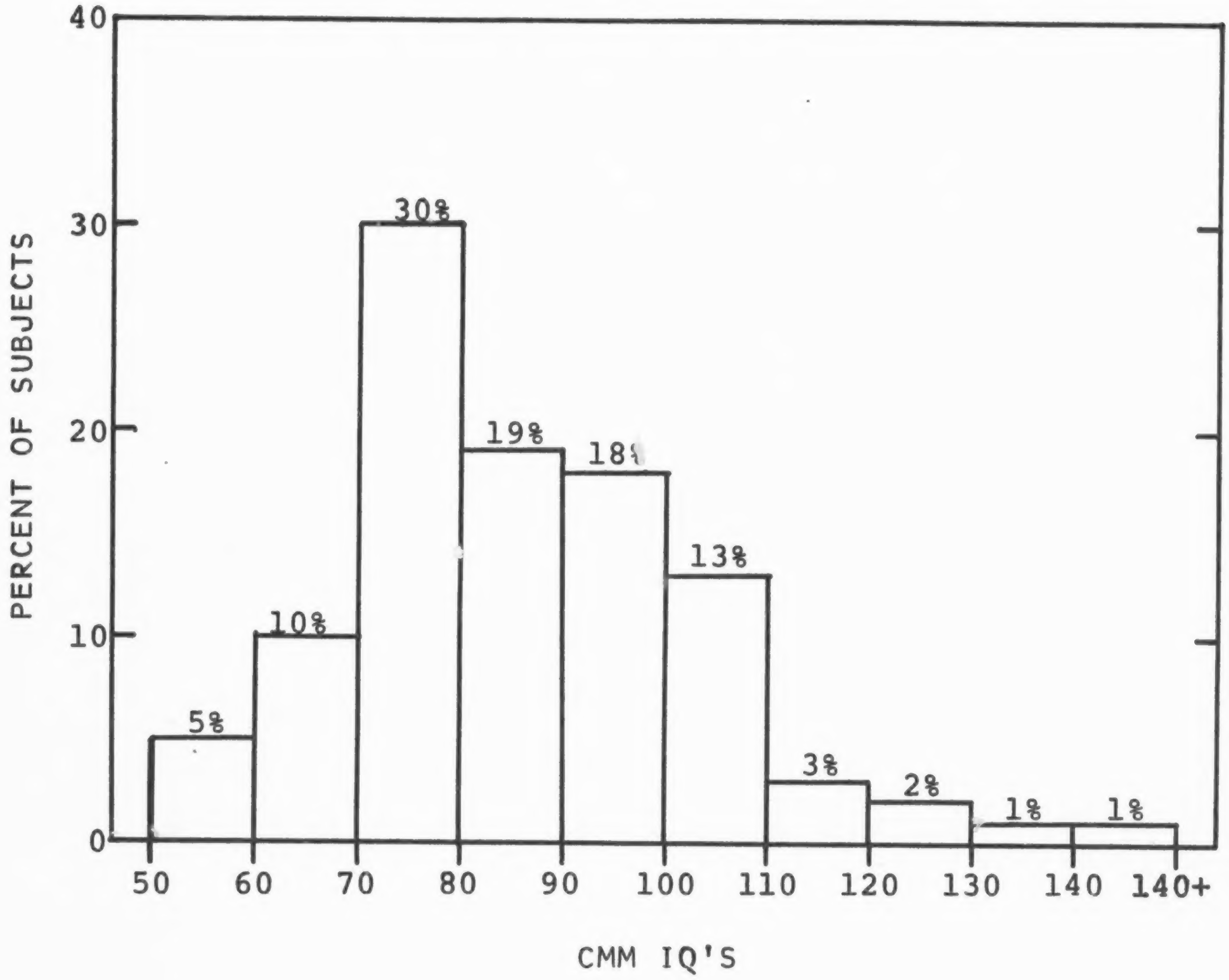

Figure 4. Distribution of CMM IQ's obtained by 199 deaf subjects.

Table 11. Mean Gates reading grade and standard deviation by age for 144 deaf subjects.

Age	Mean			SD		
	WRG	SRG	PRG	WRG	SRG	PRG
6-6 to 7-5 (N=10)	1.89	2.14	2.12	.34	.35	.24
7-6 to 8-5 (N=42)	1.99	2.29	2.07	.38	.40	.37
8-6 to 9-5 (N=43)	2.09	2.35	2.12	.46	.52	.38
9-6 to 10-5 (N=31)	2.57	2.80	2.42	.58	.36	.35
10-6 to 11-5 (N=18)	2.08	2.44	2.18	.45	.43	.38

The distributions of Gates' scores by years of deaf education are reported in Table 12. Very gradual improvement in scores can be seen in Word Recognition, Sentence Reading, and Paragraph Reading with increase in years in school.

The subjects obtained higher scores on Sentence Reading than on Paragraph Reading or even Word Recognition. Higher reading-grade equivalents for the 9-6 to 10-5 age group were obtained on Paragraph Reading than on Word Recognition. Consistent but slight improvement in all three subtests was noted through age 9-5.

Teacher Evaluation of Communicative Abilities (TECA)--Each teacher completed this evaluation on every child in her room. This scale was completed on 135 subjects. Highest possible score is 40 with 29 items on the Expressive Scale and 11 items on the Receptive Scale. Means by age and years in school are given in Table 13. Gradual improvement in scores is noted with age and with years of deaf education.

Educational Progress Rating Scale--Educational progress was estimated by the Principal on 195 subjects. The Principal rated 70 or 35.9% as below average, 88 or 45.1% as average, and 37 or 19.0% as above average.

Mean Comparisons for Groups Representing High and Low Risk for Brain Damage

Tests of visual-motor capabilities are often used as adjuncts in diagnosis of brain damage (Bender, 1938; Koppitz, 1964). Some of the etiologies present in our subject sample have been associated with risk of brain damage in normal-hearing populations; and it was hypothesized that the likely presence of brain damage in our sample would affect scores on the Bender, Frostig, and CMM. In order to test this hypothesis, a group of subjects believed to represent low risk of brain damage was identified. This low-risk group was composed of 39 endogenous deaf with no known complicating etiologies. A group representing high risk of brain damage was also selected. This high-risk group totaled 47 subjects of whom 22 had a primary etiology of prenatal rubella, 21 had a primary etiology of premature birth, and four had a primary etiology of Rh factor incompatibility.

Table 12. Years of deaf education, mean chronological age, mean reading grade, and standard deviations for the Gates Reading Tests.

Test	Years in Deaf Ed.	N	Mean CA	Mean RG	SD
Word Reading					
	1	28	9-6	1.87	.40
	2	34	8-6	1.87	.38
	3	34	8-10	2.24	.34
	4	26	9-3	2.28	.53
	5-8	24	9-4	2.57	.59
Sentence Reading					
	1	28	9-6	2.14	.50
	2	34	8-6	2.20	.36
	3	34	8-10	2.55	.31
	4	26	9-3	2.52	.44
	5-8	24	9-4	2.79	.51
Paragraph Reading	1	28	9-6	1.96	.38
	2	34	8-6	2.06	.32
	3	34	8-10	2.27	.30
	4	26	9-3	2.22	.32
	5-8	24	9-4	2.41	.44

Table 13. Mean raw scores by age and years in school for 135 deaf subjects on Teacher Evaluation of Communicative Abilities (TECA).

Age and Years in Deaf Ed.	Expressive		Receptive	
	$\bar{X}$	SD	$\bar{X}$	SD
Age				
6-6 to 7-5 (N=17)	16.8	7.9	7.4	2.3
7-6 to 8-5 (N=46)	19.8	7.4	8.2	7.9
8-6 to 9-5 (N=33)	19.4	7.5	8.9	1.8
9-6 to 10-5 (N=28)	22.1	8.1	9.5	2.2
10-6 to 11-5 (N=11)	21.0	4.8	8.6	2.4
Years				
1 (N=36)	13.7	7.1	7.0	1.9
2 (N=35)	19.9	6.7	8.1	1.8
3 (N=29)	22.0	5.9	9.1	1.6
4 (N=20)	22.8	6.2	9.3	2.5
5-8 (N=18)	24.7	6.4	9.7	2.5

Mean differences ($\alpha = .05$) between the high-risk and low-risk groups were not significant for Bender scaled scores, scaled scores on the Frostig subtests, or Frostig perceptual quotients. The mean difference in CMM IQ's between the high-risk and the low-risk groups was significant ($p < .025$).

Considering the possibility that the etiological subclassifications of the high-risk group may represent different degrees of brain-damage risk, comparisons of mean differences between the rubella group and the low-risk group and between the prematurity group and the low-risk group were performed for the Bender, Frostig, and CMM. Of these comparisons, significant mean differences were found between the rubella group and the low-risk group only for F_3 and F_5 ($p < .05$). Significant mean differences between the prematurity group and the low-risk group were found only for Bender scaled scores and CMM IQ's ($p < .01$).

Intercorrelations

For 122 subjects, complete data for all variables were available to be examined by intercorrelation. In order to maintain consistency of the sample membership and sample size in comparing correlations, only data from these 122 subjects were used.

Characteristics of the 122 subjects were as follows:

(a) Age range of time of first testing ranged from 5-8 through 10-10. Mean age was 8-4 with a standard deviation of 13.9.

(b) Fifty-six percent were male and 44% were female.

(c) Fifty percent were of Anglo-American descent, 27% were of Mexican-American descent, and 20% were of Afro-American descent.

(d) Etiology varied as follows--22% were congenital endogenous, 26% were congenital exogenous, and 41% were prelingual undetermined.

(e) Sixty-nine percent had no preschool experience, and 31% had attended preschool classes for the deaf.

Intercorrelations of all relevant variables are shown in Table 14. Intercorrelations among the tests of visual-motor perception (Bender and Frostig) were all significant

	Bender SS	Bender Raw	F_1	F_2	F_3	F_4	F_5	PQ	TSD Grade	Vis. Dec.	VMA	ME	VMS	CMM IQ	Gates Word	Gates Sen.	Gates ¶	TECA Exp.	TECA Rec.	TECA Total Eval.	Yrs. Pre-school	Yrs. Deaf Ed.	Est. IQ	Ed. Prog.	BBA_2
Bender SS	1.00	.87	-.29	-.30	-.46	-.44	-.47	-.57	-.26	-.39	-.47	-.31	-.21	-.56	-.23	-.20	-.33	-.34	-.27	-.34	-.18	-.16	-.55	-.36	.02
Bender Raw		1.00	-.20	-.26	-.29	-.26	-.25	-.37	-.47	-.33	-.43	-.34	-.22	-.43	-.38	-.39	-.46	-.41	-.40	-.42	-.13	-.30	-.42	-.21	.09
F_1			1.00	.28	.22	.23	.34	.61	.08	.24	.29	.16	.13	.25	.18	.25	.27	.31	.26	.31	.20	.04	.26	.37	-.02
F_2				1.00	.22	.29	.23	.57	-.04	.09	.22	-.03	.20	.14	.11	.10	.12	.14	.16	.15	.25	.09	.30	.23	-.07
F_3					1.00	.48	.48	.72	.07	.30	.41	.21	.27	.51	.16	.15	.21	.22	.15	.21	.32	.21	.34	.36	.14
F_4						1.00	.46	.75	.09	.27	.39	.30	.22	.45	.18	.10	.28	.27	.19	.26	.21	.11	.40	.47	.07
F_5							1.00	.71	-.08	.41	.34	.30	.25	.38	.07	.06	.15	.15	.11	.15	.23	.02	.47	.34	.01
PQ								1.00	.05	.38	.49	.31	.31	.52	.21	.21	.31	.33	.27	.33	.37	.16	.52	.53	.05
TSD Grade									1.00	.25	.27	.21	.04	.25	.64	.60	.49	.60	.52	.60	.23	.66	.16	.09	-.03
Vis. Dec.										1.00	.32	.32	.14	.31	.19	.18	.13	.34	.16	.31	.19	.17	.44	.29	-.11
VMA											1.00	.22	.25	.44	.39	.35	.45	.42	.34	.42	.23	.27	.27	.28	-.17
ME												1.00	.33	.29	.17	.31	.28	.28	.29	.29	.24	.22	.20	.22	-.03
VMS													1.00	.34	.13	.17	.25	.21	.12	.19	.19	.13	.18	.31	-.11
CMM IQ														1.00	.29	.25	.38	.28	.22	.28	.26	.25	.43	.46	.07
Gates Word															1.00	.81	.74	.63	.65	.66	.24	.49	.20	.43	-.13
Gates Sen.																1.00	.72	.58	.59	.60	.27	.48	.19	.33	-.04
Gates ¶																	1.00	.61	.66	.64	.22	.37	.29	.39	-.11
TECA Exp.																		1.00	.82	.99	.21	.41	.29	.39	-.18
TECA Rec.																			1.00	.89	.16	.36	.24	.35	-.13
TECA Total Eval.																				1.00	.20	.41	.29	.39	-.17
Yrs. Preschool																					1.00	.75	.27	.24	.19
Yrs. Deaf Ed.																						1.00	.14	.11	.09
Est. IQ																							1.00	.46	.07
Ed. Prog.																								1.00	.01
BBA_2																									1.00

Table 14. Intercorrelations for the 122 subjects who had scores on all variables.

at least at the .05 level. The tests of language ability (TECA and ITPA) showed intercorrelations significant at the .05 level or better with two exceptions. It is noteworthy that subtests for any given test were all significantly intercorrelated except Visual Decoding and Visual-Motor Sequencing.

Twenty out of 24 intercorrelations between Frostig and ITPA were significant while only 11 out of 18 intercorrelations between Frostig and TECA were significant. Bender scaled scores were significantly correlated with all subtests of the ITPA and all three parts of the TECA.

Only seven out of 18 intercorrelations between Frostig and Gates scores were significant; however, it should be noted that the Frostig PQ was significantly correlated with all three subtests of the Gates test. Bender scaled scores were also significantly correlated with all three Gates subtests. Only six of the 12 intercorrelations between the ITPA and the Gates were significant. However, the pattern of significance may be important here since the Visual-Motor Association subtest of the ITPA was significantly correlated with all three Gates subtests. The coefficient of correlation between Visual-Motor Association and Gates Paragraph Reading (.45) was the highest yielded by any standardized test used. (Bender raw score was excluded since it is not adjusted for age.) The TECA correlated most highly with the Gates test. All nine of the intercorrelations between TECA and Gates were significant beyond the .01 level and were higher (ranging from .58 to .66) than correlations of any other variables with the Gates.

Grade placement at the Texas School for the Deaf was not significantly correlated with any of the Frostig measurements; it was, however, significantly correlated with all other measures of language, intelligence, reading achievement, and visual-motor perception, except for the Visual-Sequencing subtest of the ITPA and the estimated intelligence score. Intelligence as assessed by the CMM IQ was significantly correlated with all measures of language, visual-motor perception, and reading with the exception of Frostig Subtest F_2. Years of preschool and total years of deaf education both had a rather inconsistent pattern of significances in their correlations with measures of visual-motor perception and language. However, years of preschool and total years of deaf education were both significantly related to all three subtests of the Gates. The rating of educational progress was significantly correlated with all measures of visual-motor perception, language, intelligence, and reading achievement.

The best binaural average hearing level (BBA) did not correlate significantly with any of the variables considered except years of preschool. Since this coefficient of correlation ($\underline{r}$ = .19) was only marginally significant, since it was the only one significant out of 25 possibilities, and since it did not readily lend itself to a meaningful interpretation, it is assumed to be spurious.

Multiple Correlation Analysis

The significant correlations between most of the variables measured and the Gates reading-grade scores suggested that the ability of combinations of variables to predict Gates scores should be examined. Bender scaled score, Frostig, CMM IQ, ITPA, and TECA were selected as predictor variables. The Gates Paragraph Reading score was chosen as the criterion variable since all the Gates subtests were highly intercorrelated and since Paragraph Reading has the highest face validity as a general measure of reading ability. Multiple correlations ($\underline{R}$'s) between selected combinations of the predictor variables and the Gates Paragraph Reading score are shown in Table 15.

As Table 15 illustrates, the $\underline{R}$'s ranged from .45 to .74, and all were significant ($\underline{p} < .01$). The difference between $\underline{R}$ for the visual-motor perception variables (Bender, Frostig, CMM IQ) and $\underline{R}$ for the ITPA plus TECA (.45 vs. .72) was significant ($\underline{p} < .01$). Of further interest, the difference between the $\underline{R}$ obtained using just ITPA plus TECA (.72) and the $\underline{R}$ obtained using all predictor variables (.74) was not significant even at the .10 level.

Table 15. Multiple correlations between Gates Paragraph Reading scores and selected combinations of predictor variables for 122 deaf children.

Predictor Variables	Coefficient of Multiple Correlation (R)
Bender Frostig CMM IQ	.45*
Bender ITPA	.51*
Bender TECA	.69*
ITPA TECA	.72*
Bender ITPA TECA	.72*
Bender Frostig CMM IQ ITPA TECA	.74*

*$p < .01$

Chapter V

DISCUSSION

The adequacy of visual-perceptual functioning in deaf children was measured by two clinical tests standardized on a normal population to determine first if these tests with present normative data were applicable to the deaf; second, to compare visual-perceptual functioning in deaf children to children with normal hearing; and third, to study the relationship among visual perception, linguistic ability, academic achievement, and audiological status. Of particular interest was the use of these visual-perceptual test results to identify deaf children with visual-perceptual impairment and to determine the effect of this impairment on learning ability, specifically ability to acquire linguistic skills such as reading.

Visual Perception

The two tests used to measure visual-motor perception were the Bender Gestalt Test for Young Children (Bender) and the Marianne Frostig Developmental Test of Visual Perception (Frostig). High intercorrelations were found between these two tests.[1] The coefficient of correlation between the Bender scaled score and Frostig perceptual quotient was .57 which is significant at the .01 level. This result is one of the highest correlations found among the variables examined. All five Frostig subtests correlated significantly with the Bender scaled score, the highest coefficients being between Bender and F_5 (Spatial Relations), F_4 (Position in Space), and F_3 (Form Constancy). The F_5 would be expected to be closely correlated with the Bender because both tests require copying a design--one free hand and the other connecting dots. The F_3 and F_4 deficiencies have been hypothesized to produce reversals and rotations in writing, and these are a high source of error scores as reported by Koppitz (1964). The high intercorrelation among Bender and Frostig scores indicates that both tests are measuring similar factors.

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[1] It is well known that the Bender is an inverse scale (scored for errors) and would, therefore, be expected to correlate negatively with other measures. However, for consistency and clarity, we have elected to drop the minus signs from correlations involving Bender scores.

The Bender test was apparently understood by all subjects but a disproportionately large number of deaf subjects performed at an inferior level to the hearing group on which this test was standardized by Koppitz (1964). Fifty to 60% of the deaf subjects at each level obtained scores on the first Bender test that were more than one standard deviation inferior to the mean of Koppitz' normative sample. This finding can be interpreted to mean that 50-60% of the 198 deaf subjects had visual-perceptual dysfunction or lag as measured on the first Bender.

Subjects were retested with the Bender one year after its first administration. Some subjects obtained adequate Bender scores on only one Bender, but if a subject produced Bender designs adequately at either time, it was not interpreted that visual-motor-perceptual dysfunction was present although a lag in development of visual perception was not ruled out. Therefore, if a Bender score, on either the first test or retest, fell within one year of chronological age, visual-motor perception was considered adequate as measured by the Bender.

One hundred twenty-three of the 198 deaf subjects were found to have at least one Bender score that fell within one year of their chronological age minus one year. By these standards, only 39% of the subjects had Bender scores that consistently suggested visual-perceptual lag or dysfunction. However, 39% was still considered a disproportionately high number,and, therefore, the subjects with consistently low scores were compared to the subjects with one adequate Bender score. This comparison revealed the following information:

(a) Seventy-four percent of the dull-normal population in the study had consistently inadequate scores on the Bender.

(b) Only one of the 18 subjects of superior intelligence had a Bender result one year below chronological age, and this subject was undergoing treatment for emotional problems.

(c) Forty-seven percent of the subjects of average intelligence consistently reproduced inadequate Bender scores.

(d) Twenty-three percent of the endogenous deaf population had inadequate Bender scores as compared to 32% of the rubellas, 43% of the premies, and 67% of the meningitics.

(e) Sixty-eight percent of the Afro-American population had consistently inadequate Bender scores as compared to 26% of the Anglo-American.

(f) Only 16% of the children with preschool had inadequate Bender scores.

Correlation of the Bender with other tests suggests, as do the above data, that the Bender scores are related to intelligence in the deaf child in the same way as has been observed for the hearing child. Koppitz (1964) reported that the Bender is related to intelligence until visual-motor-perceptual ability is fully matured. She found that Bender error score correlated .48 with Stanford-Binet Intelligence Scale and .79 with the Wechsler Intelligence Scale for Children. In the present study, Bender scaled scores correlated .56 with CMM IQ and .55 with estimated IQ's. This finding has implications for use of the Bender as a quick screening test of intelligence of deaf children.

Bender (1956) and Koppitz (1964) stated that the Bender test seems to be related to language ability in young children. The Illinois Test of Psycholinguistic Abilities (ITPA) subtests purport to tap factors related to linguistic ability. In the present study, only the visual-motor channel subtests of the ITPA were administered. Because both the Bender and ITPA subtests measure visual-motor functioning, and because both have been presumed to be related to linguistic ability, a relationship between Bender and ITPA scores should be expected. Significant correlations were found among all four ITPA subtests and Bender scores. Visual Decoding, Visual-Motor Association, and Motor Encoding correlated with Bender scores at the .01 level of confidence. Visual-Motor Sequencing correlated with Bender scores at the .05 level.

Language skills were also measured by a Teacher Evaluation of Communicative Abilities (TECA) which yielded a receptive language raw score, an expressive language raw score, and a total score. The Bender score correlated at the .01 level with expressive score, receptive score, and total score of the TECA.

The Bender also appears to be related to academic achievement since Paragraph Reading, educational progress, and grade placement at the Texas School for the Deaf correlated with Bender scaled scores at the .01 level.

The Bender has had long-time use as an aid in the diagnosis of neurological dysfunction (Bender, 1956; Clawson, 1962; Koppitz, 1964). We suggest caution in using Bender results to help identify neurological dysfunction in deaf children. Sixty percent of the deaf subjects obtained high error scores on the Bender and thus made many errors said by Koppitz to be significant indicators of brain injury. Also, the comparison of Bender results of subjects classified as high-risk and low-risk showed no significant differences between scores.[2]

The Frostig test was administered to 199 subjects. This test consists of five subtests that explore development in five areas of visual perception, and these five abilities purportedly develop independently and should be related to the child's ability to learn and to adjust to his environment.

According to Frostig (1964), perceptual quotients (PQ's) below 90 and scaled scores of eight and below suggest a need for remediation. Forty-three percent of the deaf subjects obtained scaled scores of eight or below on Eye-Motor Coordination (F_1); 45% obtained scaled scores of eight or below on Figure-Ground (F_2); 73% obtained scaled scores of eight or below on Form Constancy (F_3); 55% obtained scaled scores of eight or below on Position in Space (F_4); and 30% obtained scaled scores of eight or below on Spatial Relations (F_5). Deaf children's best scores were obtained on F_1, F_2, and F_5.

According to Frostig, F_2, F_3, and F_4 require only perception where F_1 and F_5 also require simple motor skills. F_1 and F_5 involve motor skills as well as perception, and these subtests are the two on which our deaf subjects most closely approximated the normative sample.

Only 17 (9%) of the sample obtained adequate scaled scores on all five subtests of the Frostig. All but two of these subjects had intelligence estimates of bright normal or above. Twelve of these 17 subjects also had preschool experiences which probably stressed development of visual-perceptual skills under general school-readiness work.

Perceptual quotients (PQ's) for the 199 subjects ranged from 58 to 129 with a mean PQ of 86. Sixty-five percent of the deaf subjects had scores below 90 which indicates a visual-perceptual lag and/or dysfunction. The 70 subjects who had average or better than average PQ's also had estimated IQ's of bright normal or above.

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[2] Low-risk: endogenous with no complications; high-risk: complications of Rh factor, rubella, and prematurity.

Assuming that the Bender and the Frostig are measuring visual-motor-perceptual skills, a lag in the development of visual-motor perception in the deaf seems clearly indicated by our data. A larger proportion of significant visual-motor-perceptual problems or dysfunction was also found in the deaf. Frostig (1964) and Koppitz (1964) both state that visual-motor-perceptual lag and dysfunction adversely affect reading achievement in hearing children. Bender and Frostig PQ correlated significantly with the Gates Primary Reading Tests and educational progress. The Bender also correlated significantly with TSD grade, but neither Frostig PQ nor any subtests correlated significantly with grade placement at the Texas School for the Deaf.

The Frostig PQ, as did the Bender, seemed closely related to intelligence as measured by the Columbia Mental Maturity Scale (CMM) (.52) and Estimated IQ (.52). Of the subtests, F_1 (Eye-Motor Coordination) and F_2 (Figure-Ground) had the lowest correlation with CMM while F_4 (Position in Space) and F_3 (Form Constancy) had the highest correlations. All subtests were significantly correlated (1% level) with Estimated IQ, but the highest correlations were found between Estimated IQ and F_3 (Form Constancy) and F_4 (Position in Space).

Of the measurements of academic skills (Gates and educational progress), only one (educational progress) takes age into consideration. Since Frostig scores are treated for age (scaled scores), it should be expected that the highest correlations would be with educational progress. Highest correlations were between Frostig PQ and educational progress (.53). Significant correlations (.01 level) were also found between Frostig PQ and Gates Paragraph Reading; between F_4 (Position in Space) and Gates Paragraph Reading; and between F_1 (Eye-Motor Coordination) and Gates Paragraph Reading.

The Frostig perceptual quotient correlated significantly (.01 level) with all of the measurements of psycholinguistic abilities. Highest correlation was with ITPA Visual-Motor Association test (.49). Frostig PQ also correlated significantly with the Teacher Evaluation of Communicative Ability. Correlations between language measurements and Frostig PQ were consistently higher than correlations between Frostig subtests and language measurements.

Linguistic Ability

The deaf subjects had no difficulty comprehending the instructions for the ITPA Visual Decoding (VisD) test, but performance was generally inferior to the McCarthy and Kirk (1961) normative sample. In the present study, the 140 subjects of comparable age to the McCarthy and Kirk normative sample obtained a mean standard score of -.63 as opposed to the normative sample mean of .00. Thirty-four percent obtained standard scores that departed negatively more than one standard deviation from .00. Rosenstein, Lowenbraun, and Jonas (1967) administered tests to a group of subjects from the New York schools for the deaf who had special communication problems. The scores of the present sample look quite similar to their findings. They reported 35% below -1.00 (we report 34%), 66% between -.99 to 1.00 (we report 62%), and 4% above 1.00 (we report 4%). For the 198 children at the Texas School for the Deaf, language ages were compared to chronological ages. No significant difference in Visual Decoding (VisD) emerged until 6-5 years. From 6-6 to 11-0, the discrepancy between chronological age and language age increased. With increase in chronological age, the deaf child, although improving in raw score and language age, falls progressively further behind hearing children. The probability of this gap's being the result of an experiential deficit that could be closed by educational experiences must be emphasized.

The deaf subjects seemed to enjoy the test of Motor Encoding (ME) in which gesturing was used to communicate what one does with the objects or pictures. The deaf child approximated the performance of the hearing subjects in the McCarthy and Kirk sample. The subjects' scores increased with age and by 9-3 and on through 11-5 the subjects were, on the average, obtaining maximum scores. Gesturing and pantomime are communication skills and, on a test that taps these forms of expression, the deaf subjects showed good knowledge of what objects were and what one did with them. Eighteen percent of our deaf subjects fell below a standard score of -1.00 which compares favorably to the 16% that would be expected in a normal sample.

The ITPA subtest of Visual-Motor Association (VMA) was the only subtest that seemed significantly difficult for the 5-6 to 6-5 age group, and scores became more inferior as age increased. Thirty-four percent of the subjects scored more than one standard deviation below the expected mean. This percentage is more than double the 16% expected from a normal sample. However, the range and distribution of scores of our subjects were quite similar to those of the Rosenstein, Lowenbraun, and Jonas (1967) sample. They reported that 37% of the deaf students they examined scored more than one standard deviation below the mean.

From age 6-6 on, the deaf subjects' scores were significantly lower than the hearing sample on the ITPA subtest of Visual-Motor Sequencing (VMS). The deaf subjects were definitely more inferior on this task in comparison to the other three subtests. Forty-three percent had scores which fell more than one standard deviation below the mean. Our subjects did somewhat better than those of the Rosenstein, Lowenbraun, and Jonas (1967) sample, but their performance was still markedly inferior to the McCarthy and Kirk normative data.

If one wishes to compare the four ITPA subtests, the following general statements can be made:

(a) At all ages, the deaf subjects' abilities to express themselves in gestures compare favorably to normal-hearing children.

(b) At younger ages, deaf subjects visually decode relatively adequately, but as age increases, a gap between deaf and hearing occurs with the deaf becoming significantly inferior to the hearing.

(c) At all ages, deaf children had difficulty making visual associations. VMA deficits, as well as VisD deficits, were found in 34% of the deaf subjects.

(d) VMS skill was deficient in 43% of the deaf subjects. However, the younger deaf subjects compared favorably to hearing subjects, but the gap widened with age.

Most of the subtests of the ITPA were significantly correlated with each other and with the TECA at or beyond the .05 level. The many significant correlations suggest that ITPA subtests are generally measuring psycholinguistic abilities that are important for language acquisition.

The four ITPA subtests all correlated significantly (.01 level) with CMM IQ, and all subtests, except VMS, correlated with estimated IQ at least at the .05 level. The ITPA subtest that correlated highest with all the academic-success variables was VMA. VMS appears to be one of the subtests least related to academic success since it correlated significantly only with educational progress and with Gates Paragraph Reading.

Low scores on the Columbia Mental Maturity Scale (CMM) appeared to be the rule rather than the exception with mean CMM IQ's falling in the 80's for our group of deaf children. Although the CMM mean IQ's were generally lower than those for the standardization sample, what apparently is being measured by the CMM was found to be significantly correlated to the visual-perceptual-test scores, estimate of intelligence, and measurements of reading and language abilities. The writers caution clinicians not to equate the IQ obtained on the CMM from a deaf child with IQ's reported for normal-hearing children. A CMM IQ in the 80's (standardization on normal-hearing children) appears to reflect average intellectual functioning in deaf children in a residential school for the deaf.

The Gates Primary Reading Tests (Gates) were the only standardized measures used to evaluate reading ability (receptive language) of our sample of deaf children. As one might expect, the scores were low. Because there are many problems inherent in the administration of any reading test to deaf children, there is some doubt as to whether the Gates actually tested the reading ability of our sample of deaf children. The very mechanics of taking such tests may defeat a deaf child since the constantly changing test instructions and the isolated bits and snatches of information are contrary to the consistent approach that is recommended for instructing deaf children. The pictures used in the Gates are often confusing to the deaf child. The small size compounded with fuzzy and often indefinite detail would be very difficult, if not impossible, for a child with a visual-perceptual handicap to attend to and to decipher. Despite these apparent inadequacies in the test, significant and positive correlation between years of deaf education and scores on the Gates was obtained. The gradual improvement in scores for the age range of 6-6 to 10-5 was encouraging. The sharp decline in Gates scores in the age group 10-5 to 11-5 was perhaps the result of a delay in educational experience of this group because 12 of the 18 subjects had two or fewer years of education.

High intercorrelations (.72 to .81) were obtained between subtests of the Gates. Significant correlations (.01 level) were obtained between the Gates tests and years of deaf education, TSD grade level, educational progress, and the TECA total score.

The TECA was specifically designed for this study with the intention of providing a quantitative measure of expressive and receptive language. The TECA scale exhibited high agreement among the expressive and receptive subtests and total score as evidenced by a correlation of .82 between expressive and receptive scores, a correlation of .89 between receptive score and total score, and a correlation of .99 between expressive score and total score. The TECA total score proved to be a good predictor of reading achievement as measured by the Gates tests. The TECA total score correlated .60, .64, and .66 with Gates Sentence Reading, Paragraph Reading, and Word Reading subtests, respectively. A significant correlation (.60) between TECA total score and TSD grade further tends to support the validity of TECA as a measurement of a deaf child's language functioning within the age and educational limits of this study.

Other tests with which the TECA total score was significantly correlated were the Bender (.42), ITPA VMA (.42), and the Frostig PQ (.33). These correlations reflect the positive relationship between visual-perceptual development and language functioning.

Audiological Status

The BBA (best binaural two-frequency average of hearing levels selected from 500, 1000, 2000 Hz) did not correlate significantly with any of the other variables. Logically, one would expect the BBA to correlate significantly with language acquisition and other measures of linguistic ability. However, the sample consisted primarily of severely hearing-impaired children with insufficient residual hearing useful for the purpose of acquiring language. In order to have meaningful correlations, a sample should include a normal distribution of BBA's from 10 dB to 110 dB plus. Obviously, this type of sample would not be found in a school established for the education of the deaf.

Multiple Correlation Analysis

All of the multiple correlation coefficients (R's) between selected groupings of predictor variables and Gates Paragraph Reading scores (Table 15) were significantly greater than zero ($p < .01$). As might be expected, the combination of all predictor variables gave the highest R (.74). However, since the R for the combination of all predictor variables was not significantly greater than R for ITPA plus TECA (.72), the ITPA plus TECA combination was clearly the most efficient group of predictor variables. In other words, if one were attempting to predict reading achievement as precisely as possible, yet at the same time as economically as possible, the best combination of predictor tests would be the ITPA plus TECA.

Chapter VI

CONCLUSIONS, IMPLICATIONS, AND RECOMMENDATIONS

Conclusions and Implications

(1) There is a reasonable certainty that some developmental lag in measurable visual-motor perception exists in young deaf children. Therefore, visual-perceptual training should be emphasized in the education of preschool-age and elementary-school-age children.

(2) Visual-motor-perceptual dysfunction is more frequently found in deaf children than in hearing children. Therefore, the functioning of the visual-motor-perceptual channel should be evaluated as carefully as the degree of hearing impairment, intellectual capacity, and language development.

(3) Evidence from this study does not support the contention that the lag and/or dysfunction in visual perception among deaf children is a result of brain damage. Therefore, Bender and Frostig scores cannot be considered efficient diagnostic indicators of neurological functioning in deaf subjects. We conclude that the visual-motor-perceptual lag may be a consequence of auditory deprivation or, at least, it may be related to auditory deprivation in that this visual-motor-perceptual lag reflects an experiential gap.

(4) The deaf child who functions at a superior or bright-normal level on performance tests of intelligence has a greater probability of not having a visual-perceptual lag than a dull-normal deaf child. Deaf children who functioned on individual performance tests at a dull-normal intellectual level had a high incidence of visual-motor-perceptual problems. Therefore, a systematic program of instruction in visual perception should be provided for all deaf children functioning below an IQ of 90. Most of these children will need additional sense-training-readiness work and perhaps even special modification of curricula in order to compensate for their deficits.

(5) Preschool experience appears to result in improved functioning on some visual-perceptual tests. Preschool experiences apparently emphasize visual-perceptual development, and, therefore, this opportunity should be provided for all deaf children with visual-perceptual problems.

(6) A larger percentage of deaf children than hearing children had deficits in the measured visual-motor skills necessary for language acquisition (exception--motor encoding). Differences between deaf and hearing subjects on ITPA visual-motor subtests were less at younger ages than for older age groups. Therefore, for the children with deficits, remediation in visual decoding, visual-motor association, and visual-motor sequencing should continue through older age groups of deaf children.

(7) Visual memory was found to be deficient in 43% of the deaf subjects examined in this study. Therefore, a systematic program of exercises to increase visual-memory skills might help a significant proportion of deaf children. It cannot be taken for granted that a deaf child who has to rely on vision will automatically develop good visual retention.

(8) Deaf children express themselves in gestures generally as well as hearing children. In this study, the deaf children performed better on Motor Encoding than on any other measurement. Therefore, motor-encoding ability should be utilized to assess concept learning in the deaf, and the development of this ability should provide an improved feedback mechanism. Drama, charades, etc. should also allow self-expression at a level appropriate to a child's chronological age.

(9) Linguistic skills, as measured on a developmental scale by the classroom teacher correlated significantly with measured reading ability, placement at the Texas School for the Deaf (TSD grade), and estimated educational progress. Therefore, refinement of the TECA and its use in evaluation of a deaf child's development of language appears justifiable.

(10) Reading ability and academic progress were probably not thoroughly assessed by the test instruments used in this study. Therefore, we recognize a need for a more sensitive differential diagnostic test battery that would help determine why a deaf child is having difficulty learning to read.

Recommendations

(1) Differential diagnostic testing of a deaf child should include assessment of visual-motor-perceptual functioning.

(2) If a deaf child is found to be deficient in a visual-motor skill, remediation should be integrated into his educational program.

(3) The adaptation and extension of existing programs in visual-motor perception should be provided for deaf children.

(4) The effects of visual-perceptual remediation on performance test scores and reading achievement should be studied systematically.

(5) The study summarized in this report should be replicated on deaf subjects with a greater range of hearing levels in order to determine to what extent visual-perceptual integrity is dependent on auditory perception and language acquisition of deaf children.

(6) Normative data on visual-perceptual measurements should be gathered from a cross-sectional sample of schools for the deaf.

(7) Corroborative studies of Bender performance by neurologically-involved and non-neurologically-involved deaf children should be carried out.

(8) Since there appears to be a fairly high incidence of visual-perceptual deficits among residential-school deaf children, teachers of the deaf should be knowledgeable about diagnostic and remedial aspects of visual-perceptual impairment.

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APPENDICES

APPENDIX A

Special Instructions for Administering the Bender Gestalt Test to Young Deaf Subjects

1. Place two sheets of unlined white paper and a No. 2 pencil with eraser in front of the subject.

2. Expose briefly the nine Bender cards to the subject, and place these face down above the subject's papers.

3. Two sheets of paper, a pencil, and sample cards [(a) ∞, (b) Δ, (c) +] are placed in front of the examiner. The examiner carefully copies these designs for demonstration purposes.

4. The examiner next points to the subject's card and paper, then turns over Card A, hands the subject his pencil, and nods.

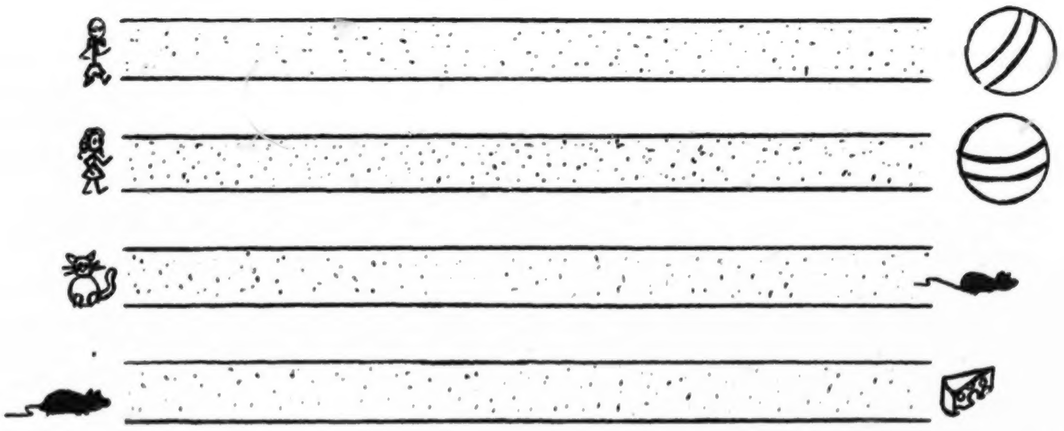
5. Koppitz' instructions are followed for the remainder of the test.

APPENDIX B

Supplementary Instructions Used in Administering the Frostig Test to Young Deaf Subjects*

General Instructions--Seat the subjects at tables--not desks. Arrange seating in such a way that no one subject can see another subject's test booklet. Give each subject a No. 2 pencil with no eraser, four colored pencils, and a test booklet with the child's name and date on it. Immediately show the subjects that the test booklet is not to be opened until the examiner so instructs.

Special Instructions for F_1--Use overhead-projector slides or reproduce on a blackboard the following demonstration items for F_1.



Demonstrate with gestures directions for the Frostig F_1. Another examiner attempts to follow these directions, making several possible mistakes. These mistakes are immediately corrected; finally, the examiner taking the test follows directions exactly. At this point, ask a child or two to show the correct way to draw the lines.

Place the Frostig Page 1 transparency on the overhead projector, repeat directions, and have the children open their test booklets and begin.

When the type of problem changes, demonstrate as described above.

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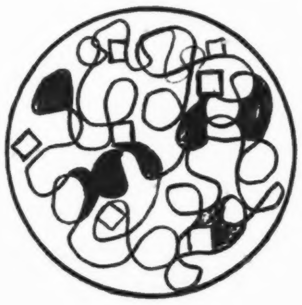
*These instructions are supplementary to the Frostig Test Manual instructions.

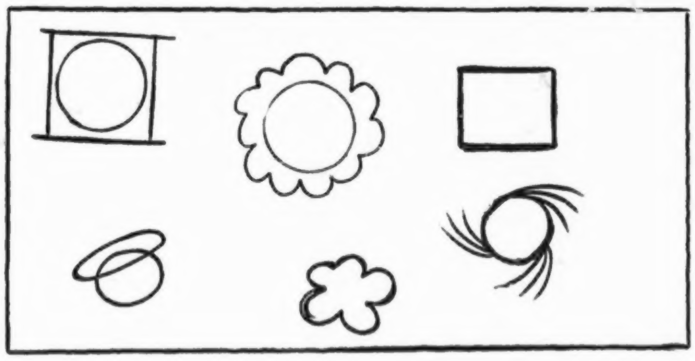
Special Instructions for F_2--First, teach the concept of outlining to the subjects. Demonstrate with a triangle. Then continue, following Frostig instructions.

Precede Items 7 and 8 with the following demonstration item:

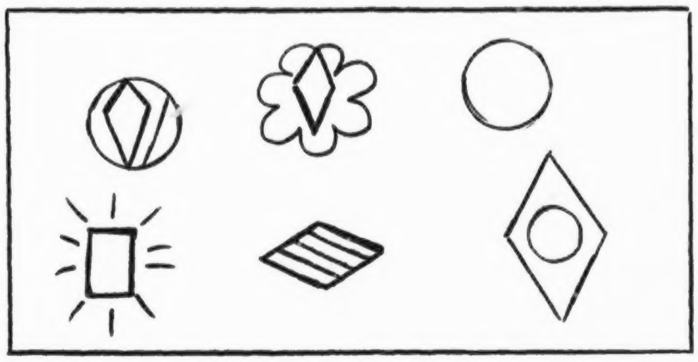


Outline the squares.

Special Instructions for F_3--Explain that the subjects are to look at all the pages and then outline. Stress the need for a survey of the whole page. Use the following demonstration drawings:



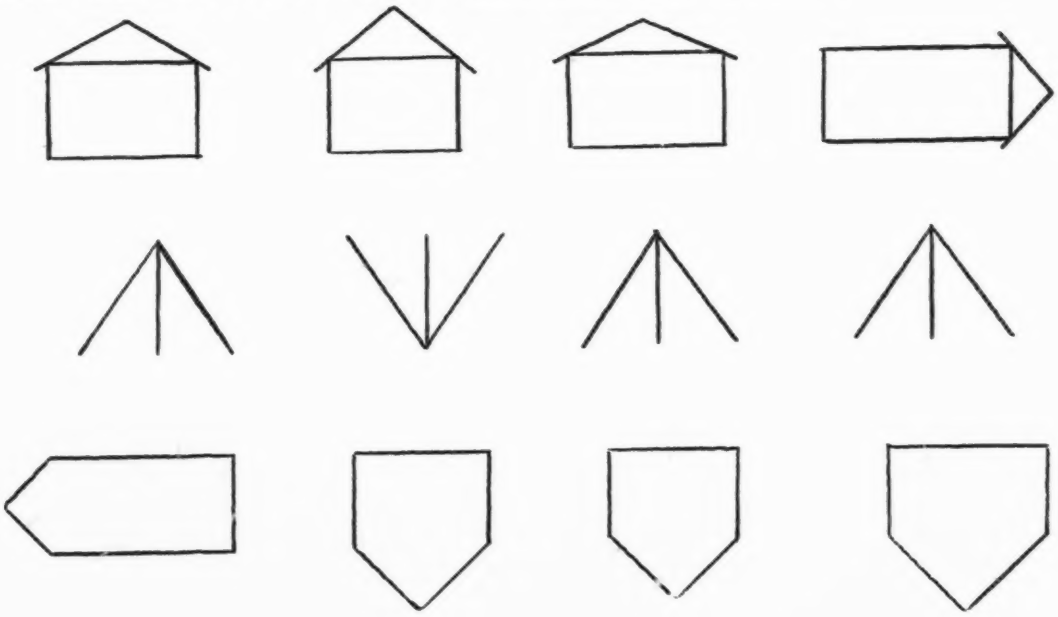
Outline the balls.



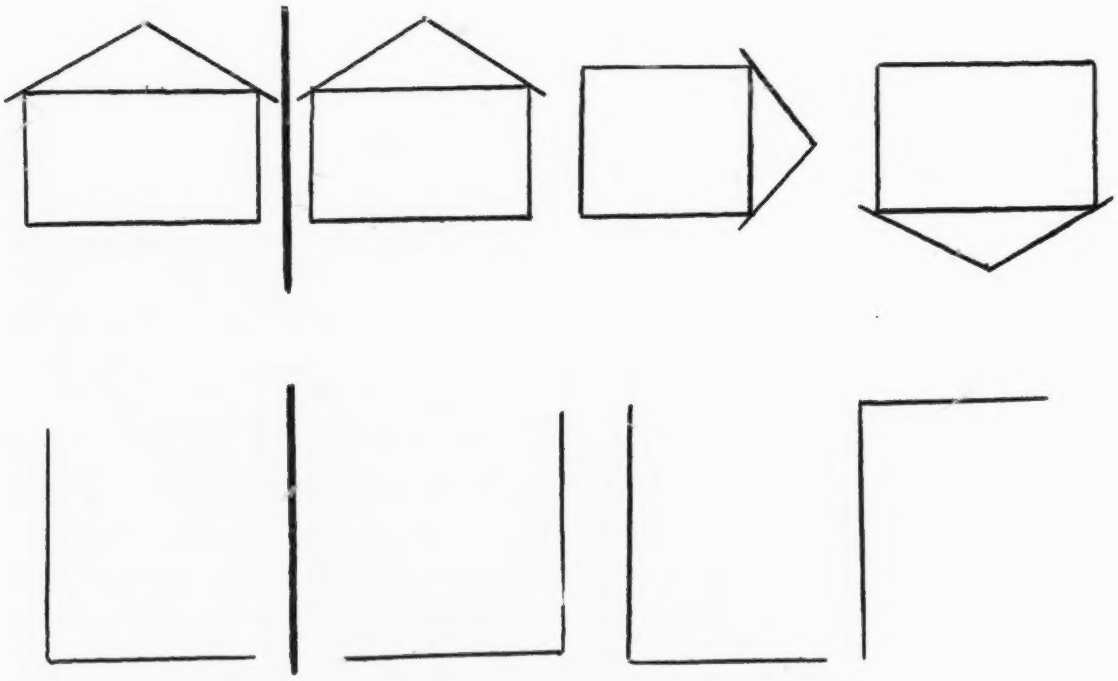
Outline the kites.

Special Instructions for F_4--Prior to administration of this test, use the following demonstration items.

Part A:



Part B:



Special Instructions for F_5--Demonstrate Item 1 on the blackboard.

APPENDIX C

Special Instructions for Administering the Gates Reading Tests to Young Deaf Subjects*

The test manuals and the following additional instructions were used in testing:

1. Plan seating arrangement to prevent any child's seeing another child's test booklet.
2. Pass out subtest booklet and No. 2 pencil to each child. Instruct children to write their name and the date on the cover of their test booklet.
3. Place practice material on the overhead projector. Each child should be given an opportunity to respond to the practice material.
4. Children then complete practice section on cover of subtest. Examiner and proctor check each child's response. Errors should be noted and practice material repeated if needed.
5. The examiner should show the complete subtest to the child, emphasizing all the pages the child will complete.
6. Each subtest should be timed, and booklets should be collected at the end of the period.

Children were encouraged to answer all items but discouraged from guessing.

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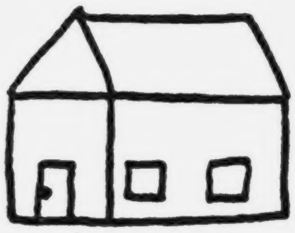
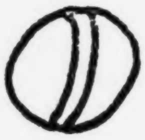
*Instructions were identical for practice material on Word Recognition, Sentence Reading, and Paragraph Reading.

Supplementary Demonstration Items for Gates Primary Word Recognition



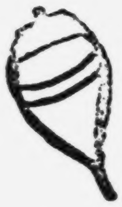
woman house

mouse chair



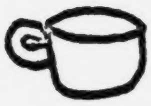
saw fall

call ball



ball stop

top chair



walk cup

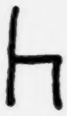
come chair

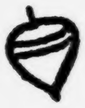
Supplementary Demonstration Items for Gates Primary Sentence Reading

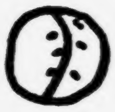
This is a ball. I

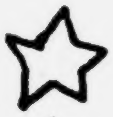
This is a chair. II

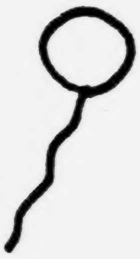
This is a balloon. III

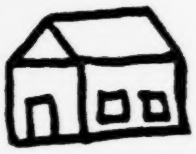








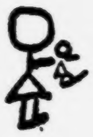


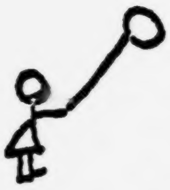


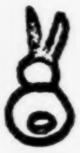
The girl has a balloon. I

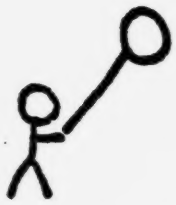
The boy has an airplane. II

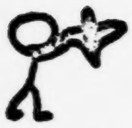
This is a rabbit. III

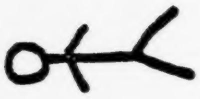




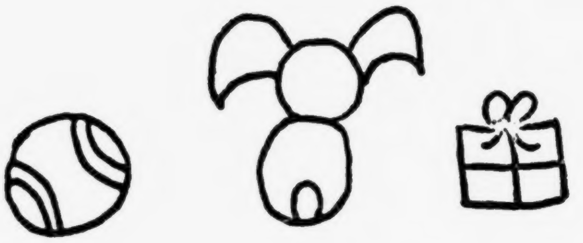




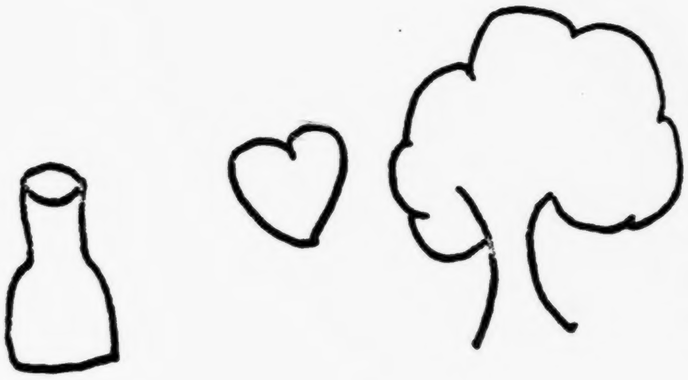




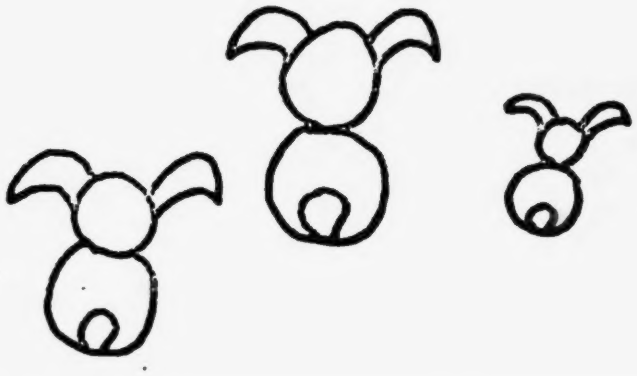
Supplementary Demonstration Items for Gates Primary Paragraph Reading



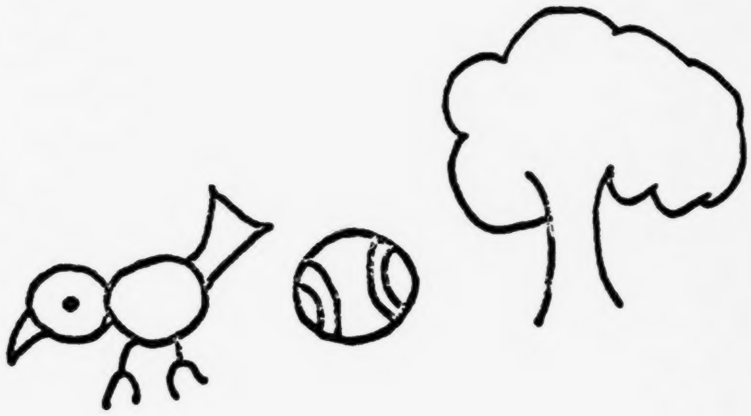
1. Put an X on the rabbit.



2. Put an X on the tree.



3. Draw a line under the little rabbit.



4. Draw a line from the bird to the tree.

APPENDIX D

Special Instructions for Administering the Teacher Evaluation of Communicative Abilities (TECA)

The TECA was designed to be used as an evaluation instrument by classroom teachers, and satisfactory completion was dependent on familiarity with and extended observation of the child. Teachers were instructed to "set up" situations that would aid in gathering information about each child. Pictures were presented on an individual basis. The teachers were directed to accept and credit the child with all meaningful communication regardless of the form.

Name:
Date:
Grade:
Teacher:

TEACHER EVALUATION OF COMMUNICATIVE ABILITIES

E ___ 1. Crows, laughs, or smiles

E ___ 2. Repetition of sound;reflexively-spontaneous imitation of vowel sounds or ubububu

E ___ 3. "Talks," imitate sounds spontaneous imitation of sounds presented in speech or speechreading
___ Finger spelling for manual children
___ Appropriate sign

R ___ 4. Responds to name or "no" through speechreading or hearing
___ Finger spelling for manual children

R ___ 5. Comprehends "Bye-bye" through speechreading or gestures

E ___ 6. Echoes words or sounds--spontaneous imitation of animal sounds, syllables, nouns presented through hearing or speechreading
___ Finger spelling for manual children
___ Appropriate signs

R ___ 7. Follows a few simple directions presented through speechreading or hearing--i.e., run, jump, or other simple commands
___ Finger spelling for manual children

E ___ 8. Expressive vocabulary of one word--i.e., "no," "mama," "bye" (not imitative but spontaneous)
___ Finger spelling for manual children
___ Appropriate sign

E ___ 9. Expressive vocabulary of two words, i.e.: "I'm through," "Thank you," "I know," "I'm sorry," "I'm sick," "That's mine," "I'm cold," "That's pretty," "That's good"
___ Finger spelling for manual children
___ Appropriate signs

R ___ 10. Recognizes names of a few familiar objects (people or things) through speechreading and/or hearing
___ Finger spelling for manual children

E ___ 11. Expressive vocabulary of 10 words, including names--uses a vocabulary of few words spontaneously, i.e., Hello, Bye-bye, water, bathroom, names of toys, names of teacher or children, verbs, etc.
___ Finger spelling for manual children
___ Appropriate signs

E ___ 12. Uses up to three words per sentence. Spontaneous use of "I got a box," "Mother come after while," "Go home after while," "_____ is sick," "May I come," for example.
___ Finger spelling for manual children
___ Appropriate signs

E ___ 13. Names many common objects, i.e., can name spontaneously all nouns presented in speech. Imitates noun presented in speechreading.
___ Finger spelling for manual children
___ Appropriate sign

E ___ 14. Uses I, me, mine, we, other pronouns.
___ Finger spelling for manual children
___ Appropriate sign

E ___ 15. Expressive vocabulary of twenty words. Uses words that have been presented in a meaningful fashion.
___ Finger spelling for manual children
___ Appropriate sign

E ___ 16. Can name at least three common pictures, i.e., cup, dog, shoe, house, sun, pop, car, flower, boat, tree
___ Finger spelling for manual children
___ Appropriate sign

R ___ 17. Identifies five of the above pictures through speechreading and/or hearing.
___ Finger spelling for manual children

E ___ 18. Gives full name (when asked "What is your name?")
___ Finger spelling for manual children

E ___ 19. Comprehends and asks for "another" (more). Child understands need of (for example) additional paper to complete work, or another item in passing out material, etc., and can ask for it by using a single word (such as child's name) or phrase that will let the teacher know needs. Gestures not accepted.
___ Finger spelling for manual children
___ Appropriate sign

R ___ 20. Can correctly respond to three parts of the body through speechreading and/or hearing, i.e., arm, thumb, toe, eye, mouth, tooth, foot, feet, knee, face, hair, nose, hands, ear, leg
___ Finger spelling for manual children

E ___ 21. Uses plurals
___ Finger spelling for manual children

E ___ 22. Verbalizes toilet needs.
___ Finger spelling for manual children
___ Appropriate sign

E ___ 23. Relates experiences through pantomime or speech.

E ___ 24. Has mastered m, p, b, wh, and w sounds in speech.

R ___ 25. Understands concept of taking turns.

E ___ 26. States own sex when asked if boy or girl as: "Are you a boy?" "Are you a girl?"
___ Finger spelling for manual children
___ Appropriate sign

E ___ 27. Names almost all common pictures (Gesell card) (Card 1--cup, dog, shoe, house; Card 2--pop, flower, car, sun, tree, boat)
___ Finger spelling for manual children
___ Appropriate sign

R ___ 28. Knows at least one nursery rhyme (identification through speechreading--child identifies picture of rhyme).
___ Finger spelling for manual children

R ___ 29. Can identify five objects by definition of their use through speechreading (something to eat, something to play with, something to use, etc.)
___ Finger spelling for manual children

E ___ 30. Vocalizes well over 50 words from list below, spontaneous vocalization when objects or picture are shown.

___ Finger spelling for manual children

ball
bow
bee
bus
boat
comb
cocoa
fish
fork
knife
horse
rabbit
dog
key
mouse
flower
moon
pie
pop
top
water
arm
eye
turkey
hen
popcorn
car
cow
cup
cat
gun
gum
house
puppy
soap
sheep
ice cream
cake
butter
boy
baby
man
woman
shoe
pig
candy
cookie
milk
tree
dress
wagon
chair
airplane
book
barn
kite
doll
leaf
lamb
plum
soup
apple
bed
box
pencil

R ___ 31. Executes three commissions. The three are given in speechreading and the child retains the three directions, executing them in order.

___ Finger spelling for manual children

E ___ 32. Knows one color in speech.

___ Finger spelling for manual children

___ Appropriate sign

R ___ 33. Repeats four digits (read series 1 sec. apart)

___ Finger spelling for manual children

E ___ 34. Knows penny, nickle, dime (child recalls speech from objects).

___ Finger spelling for manual children

E ___ 35. Has mastered t, d, n, k, g, and ng sounds in speech

E ___ 36. Knows all primary colors (spoken form given when color is shown).

___ Finger spelling for manual children

___ Appropriate sign

E ___ 37. Calls attention to own performance

E ___ 38. Relates fanciful tales through pantomime, speech and/or drawing

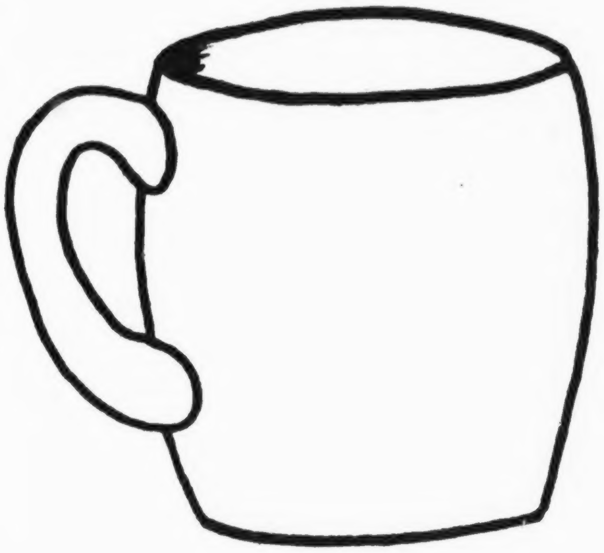
E ___ 39. Can explain use of three or four objects (when asked "What is this for?")
crayons--draw
bus--to ride
rain boots--for rain
cup--water, drink
spoon--eat
___ Finger spelling for manual children
___ Appropriate sign

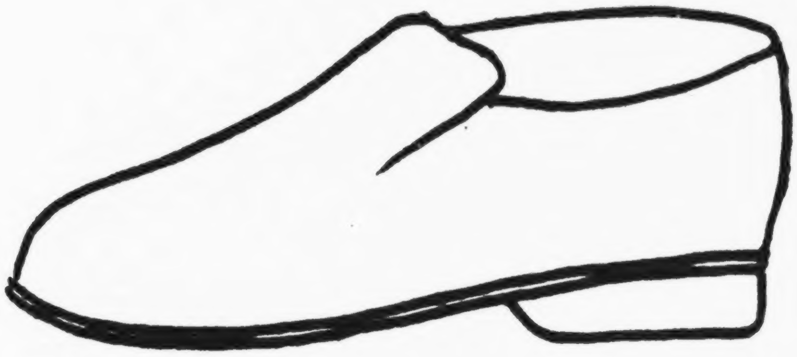
E ___ 40. Asks meaning of words. (Child may say, "What's that.")
___ Finger spelling for manual children
___ Appropriate sign

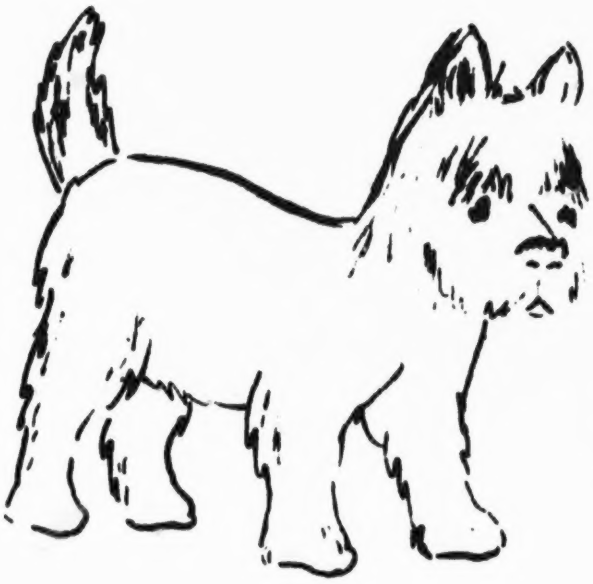
Key: E--Expressive--(output--vocalizes, uses speech, talks)
finger spelling, appropriate sign

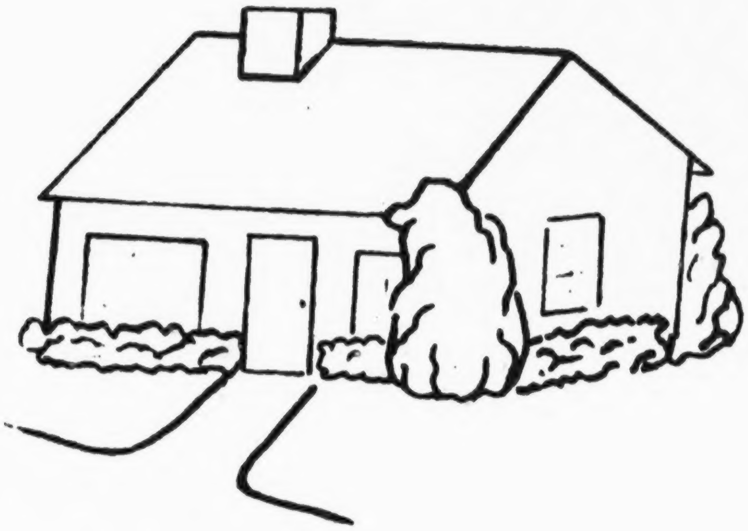
R--Receptive--(input--understands speech, speechreading)
finger spelling

CARD 1

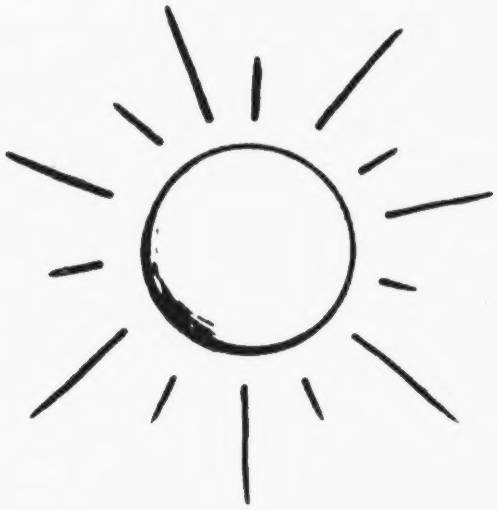


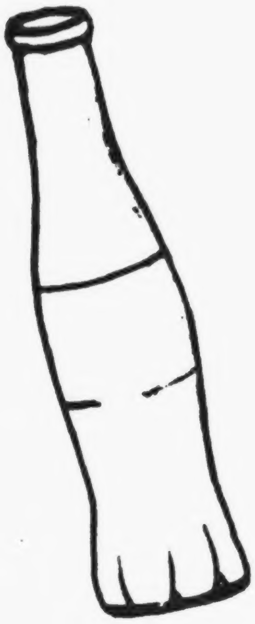


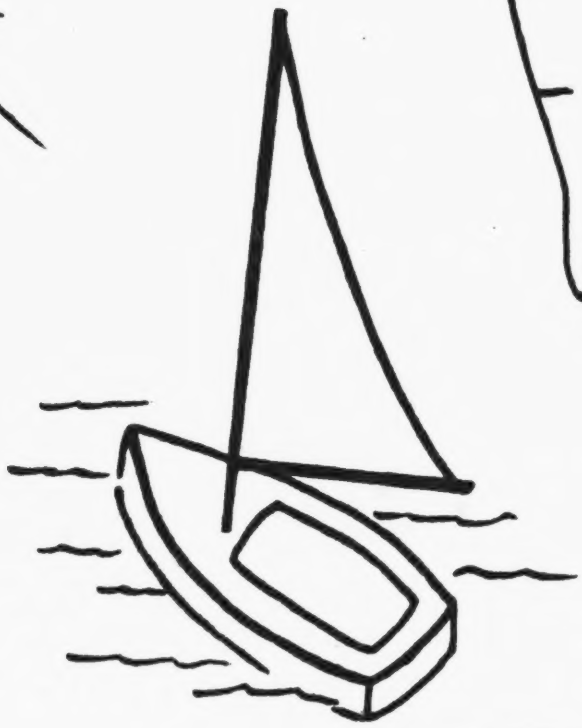


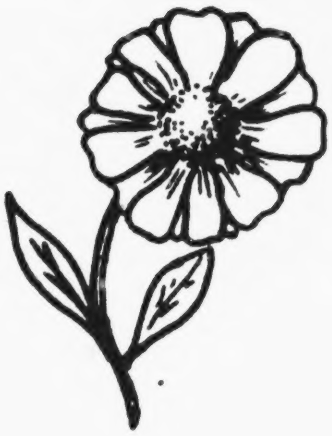


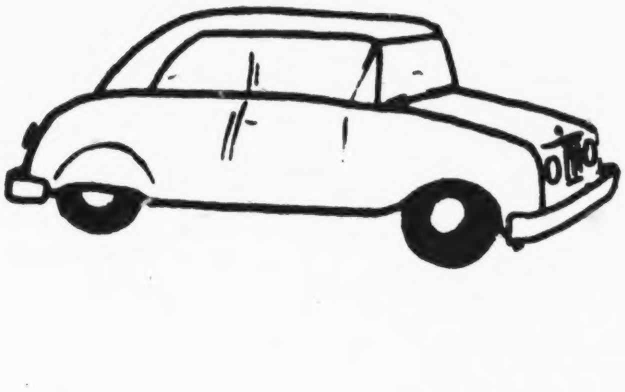
CARD 2

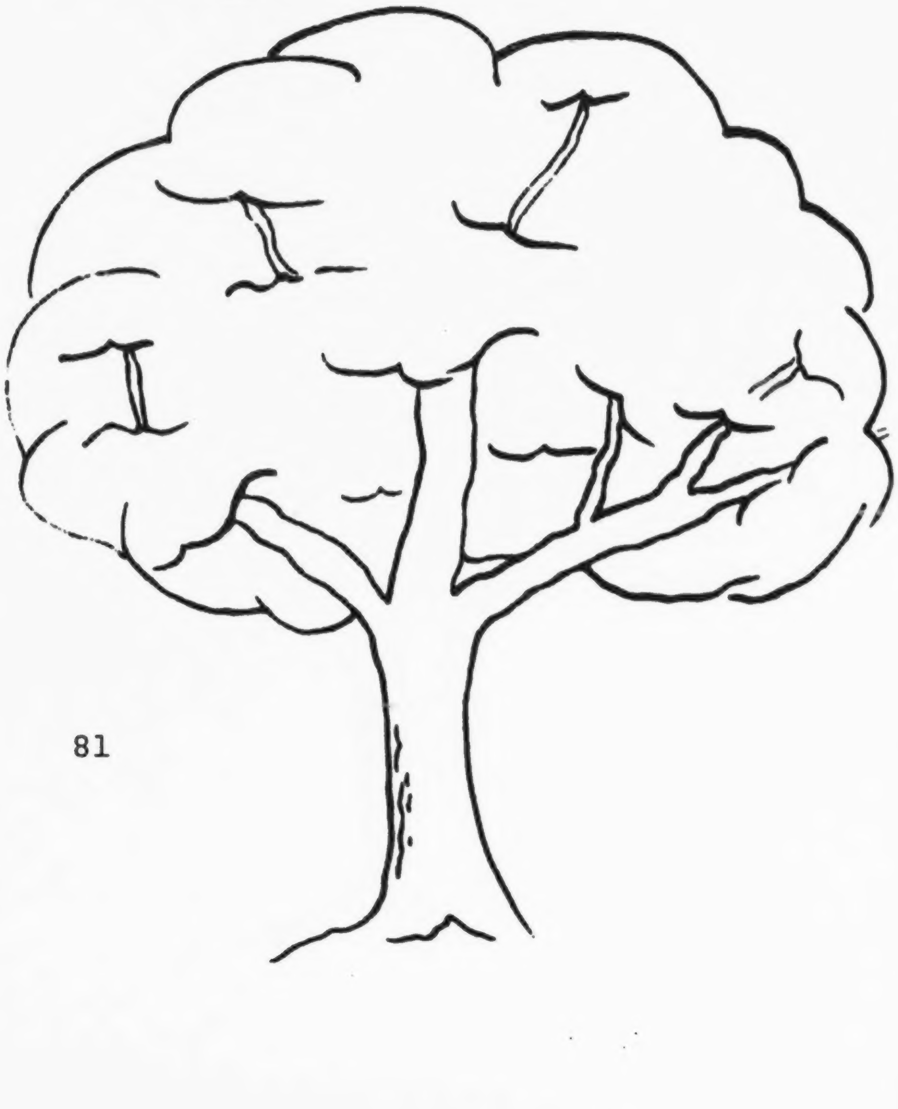












APPENDIX E

Computational Procedures

Correlations

Bivariate relationships were evaluated by computation of Pearson's product-moment coefficient of correlation ($\underline{r}$) which is defined by:

$$\underline{r} = \frac{\left(\sum_i X_i Y_i / N\right) - M_X M_Y}{S_X S_Y}$$

X_i and Y_i are raw scores for the i-th individual on the two variables being correlated; N is total number of subjects; M_X and M_Y are the respective means for the two variables, and S_X and S_Y are the respective standard deviations of the two variables being correlated (Hays, 1963).

Scaled Scores

Scaled scores for the Bender Gestalt Test for Young Children were obtained by multiplying the z-score for each individual by ten and adding 50 to each z-score. Since the z-scores referred to here were computed with respect to each one-year age group, this transformation gives a set of scaled scores having a mean of 50 and a standard deviation of ten for each age group.

Multiple Correlations

Coefficients of multiple correlation ($\underline{R}$) were computed using an iterative procedure described by Veldman (1967). The scores for the predictor variables (X_n) are combined in a linear fashion to yield a prediction ($\hat{Y}$) of the obtained scores on the criterion variable (Y). The equation for this combination is

$$aX_1 + bX_2 + cX_3 + \ldots + nX_n = \hat{Y}$$

where X_n are raw scores for the predictor variables; a, b, c ... n are regression constants and $\hat{Y}$ is the distribution of predicted criterion scores. The product-moment coefficient of correlation between $\hat{Y}$ and Y is maximized by a series of adjustments in the values assigned to the regression constants. The results of this procedure yield an extremely close approximation to the classical computation of R which maximizes the correlation between $\hat{Y}$ and Y by solving algebraically for the values of the regression constants.

t tests

The t tests reported were done by the Scheffé method of post-hoc comparisons (Hays, 1963). Given K groups from which we may select J groups ($J \leq K$) for comparisons, the J groups may be selected and combined in any desired way to produce two-group contrastive comparisons (e.g., given groups 1, 2, 3, 4, 5, and 6; comparisons such as 1, 2 vs. 3, 4, 5; 1, 5 vs. 3; 2 vs. 5; 5, 1 vs. 2; etc., may be considered). For a given contrastive comparison, g, a linear combination ($\hat{\Psi}_g$) of the J sample means involved (M_j) is computed by assigning positive weights (c_j) to the means combined in one group and assigning negative weights (c_j) to the M_j in the contrasted group:

$$\hat{\Psi}_g = \sum_j c_j M_j$$

with the further restriction that

$$\sum_j c_j = 0$$

Thus, $\hat{\Psi}_g$ is an estimate of the mean difference between two groups weighted by the number of means combined to form each of the two contrasted groups. Next, an interval estimate of the true value (Ψ_g) of the mean difference between the two contrasted groups is established by use of the confidence interval:

$$\hat{\Psi}_g - S\sqrt{V\hat{\Psi}_g} \leq \Psi_g \leq \hat{\Psi}_g + S\sqrt{V\hat{\Psi}_g}$$

where

$$V\hat{\Psi}_g = \left[\frac{\sum_K \sum_n (X_{Kn} - \bar{X}_K)^2}{K(n-1)}\right]\left[\sum_j \frac{c_j^2}{n_j}\right]$$

and

$$S = \sqrt{(J-1) F_{\alpha}}$$

It should be noted that in the above relation, K refers to the original K groups from which the J groups of interest were selected and $\underline{n}$ refers to the number of subjects within such a group. The F_{α} refers to the tabled value of F at the selected α level with J minus 1 and N minus J degrees of freedom where N is total subjects in all J groups.

If the interval estimate of Ψ_g excludes zero, then the comparison under consideration is significant at the α level of confidence.